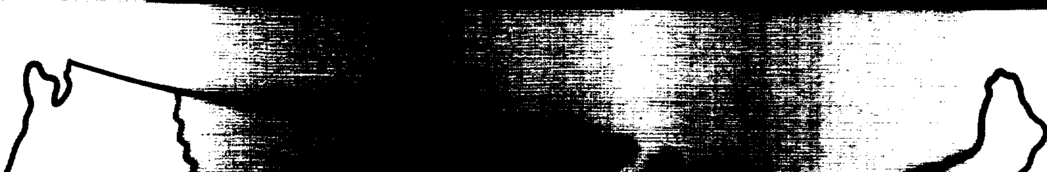
ARCS V

Remedial Activities at Uncontrolled Hazardous Waste Sites in Region V

EPA United States Environmental Protection Agency



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Work Plan for the
Engineering Evaluation/Cost Analysis and
Remedial Investigation/Feasibility Study

Kerr-McGee Residential Areas

West Chicago, Illinois

WA 71-5LQV/Contract No. 68-W8-0040
February 1994

OROKM8/049.WP5

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(continued)

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Acronyms

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARARs	applicable or relevant and appropriate requirements
CA	Cost Analysis
CART	classification and regression trees
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSL	close support laboratory
CWA	Clean Water Act
DBMS	Database Management System
DOE	Department of Energy
DQO	Data Quality Objective
EE	Engineering Evaluation
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FS	Feasibility Study
FSP	Field Sampling Plan
FTE	full time equivalent
GIS	Geographical Information System
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HPGe	high purity germanium detector
HSP	Health and Safety Plan
IDNS	Illinois Department of Nuclear Safety
IRIS	Integrated Risk Information System
NCP	National Contingency Plan
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
mph	miles per hour
NESHAPS	National Emission Standards for Hazardous Air Pollutants
QA	quality assurance
QC	quality control
OSWER	Office of Solid Waste and Emergency Response
PARCC	precision, accuracy, representativeness, completeness, and comparability
PIC	pressurized ion chamber
PRP	potentially responsible party
RA	remedial action
RAGS	EPA Risk Assessment Guidance for Superfund
RD	remedial design
RI	Remedial Investigation

Acronyms
(continued)

RKP	Reed-Keppler Park
RME	reasonable maximum exposure
RMP	Radon Measurement Proficiency
Rn	radon
ROD	Record of Decision
RPISU	radon progeny integrating sampling unit
SACM	Superfund Accelerated Cleanup Model
SAP	Sampling Analysis Plan
SD	standard deviation
SPCS	Superfund Project Control System
STP	Sewage Treatment Plant
TBC	to be considered
TM	Technical Memorandum
Tn	thoron
UCL	upper confidence limit
WMP	Waste Management Plan

Section 1
Introduction

CH2M HILL has prepared this work plan for the United States Environmental Protection Agency (EPA) under authorization of EPA contract number 68-WA-0040 and Work Assignment No. 71-5LQV. This plan defines the scope, budget, and estimated schedule for CH2M HILL to prepare an Engineering Evaluation/Cost Analysis (EE/CA), define the areas of contamination requiring removal through discovery and characterization sampling, and conduct the Remedial Investigation (RI) and Feasibility Study (FS) for the Kerr-McGee Residential Areas site in Illinois.

An EE/CA is used to evaluate removal action alternatives and is required under the National Contingency Plan (NCP) prior to conducting non-time-critical removal actions for a site. Non-time-critical removal actions, which may be interim or final actions, respond to contaminated sites that pose a threat to human health or the environment. The purpose of an EE/CA is to document the selection of a response action and to provide a vehicle for public involvement in the selection process. The purposes of the RI are (1) to determine the nature and extent of residual chemical and radiological contamination at the Residential Areas site that remain after the removal and (2) to provide data to support a human health residual risk assessment and the FS. The purpose of the FS is to develop and evaluate appropriate final remedial action alternatives for protection of human health and the environment.

This work plan details the technical approach, personnel and equipment requirements, and schedule for implementing the EE/CA, the discovery and characterization sampling, and the RI/FS. A preliminary site evaluation is presented that includes a description of the site background and environmental setting, the present nature of contamination, probable migration pathways, and potential receptors. Sampling rationale are developed on the basis of the following:

- Conceptual site model
- Preliminary risk assessment
- Preliminary remedial action technologies

Section 1 of this work plan presents the project background, an evaluation of the needed data, the project objectives for the EE/CA and the RI/FS, and a summary of the project activities. Section 2 describes the tasks for this project, Section 3 the schedule, Section 4 the budget, and Section 5 the project team organization for conducting the EE/CA, the discovery and characterization investigation, and the RI/FS.

Site Background

The Kerr-McGee Residential Areas site encompasses residential, institutional, commercial, and municipal properties in and around West Chicago, Illinois. Thorium mill tailings from the current Kerr-McGee Rare Earths Facility were used for various purposes in the area, and exposure to the residual radiation is a primary concern. The site is one of four on the National Priorities List (NPL) contaminated with radioactivity from thorium and its decay products from ore processing operations at the factory. Properties within the Residential Areas site study area are located as shown in Figure 1-1. The site boundary is identified in the figure and is defined as the boundary of elevated gamma readings from a 1989 aerial radiological survey (flyover) by EG&G. Note that areas of elevated gamma activity that are exclusively part of the Kress Creek/West Branch DuPage River site (one of the four sites on the NPL) are not shown in the figure.

From approximately 1932 to 1973, the factory site was operated as a thorium extraction facility for various purposes. Lindsay Light and Chemical Company operated the facility from 1932 until 1958, extracting thorium and other elements from monazite sands for the manufacture of gas mantels and hydrofluoric acid, as well as supplying thorium, radium, uranium, and rare earths to private parties and the government. Ownership of the processing facility changed through corporate mergers, becoming American Potash and Chemical Company in 1958, while the production of thorium continued. In 1967, Kerr-McGee purchased the facility and maintained operations until its closure in 1973.

Production of thorium, a radioactive material, yielded radioactive tailings, primarily containing thorium (Th-232) and residual levels of radium (Ra-226 and Ra-228). These tailings were stockpiled at the factory site. Prior to any regulation and possibly later, the tailings were available for use as fill material at residential and other properties throughout the West Chicago area, resulting in widespread surface and subsurface contamination of soils. In addition, piles of the material were subject to wind dispersal. In 1954, thorium production became subject to federal regulation with the passage of the Atomic Energy Act by the U.S. Atomic Energy Commission (AEC). The operating license for the facility was transferred to Kerr-McGee when it purchased the facility in 1967. In 1974, under the Energy Reorganization Act, the AEC was abolished and the Nuclear Regulatory Commission (NRC) was created in its place.

In 1984 and 1985, Kerr-McGee and the City of West Chicago, under a voluntary cleanup program, removed radioactive materials using a radiation exposure rate criterion of 30 microroentgen per hour (μR/hr) at 1-m height to initiate cleanup from properties in the incorporated areas of West Chicago. The thorium residuals were placed at the factory site for storage. Properties outside of the incorporated area and a few other miscellaneous properties were not remediated; therefore, thorium residuals exceeding the company exposure rate criterion still exist throughout the area. In October 1984, the Residential Areas site was proposed for the NPL and was finalized on the NPL in August 1990.

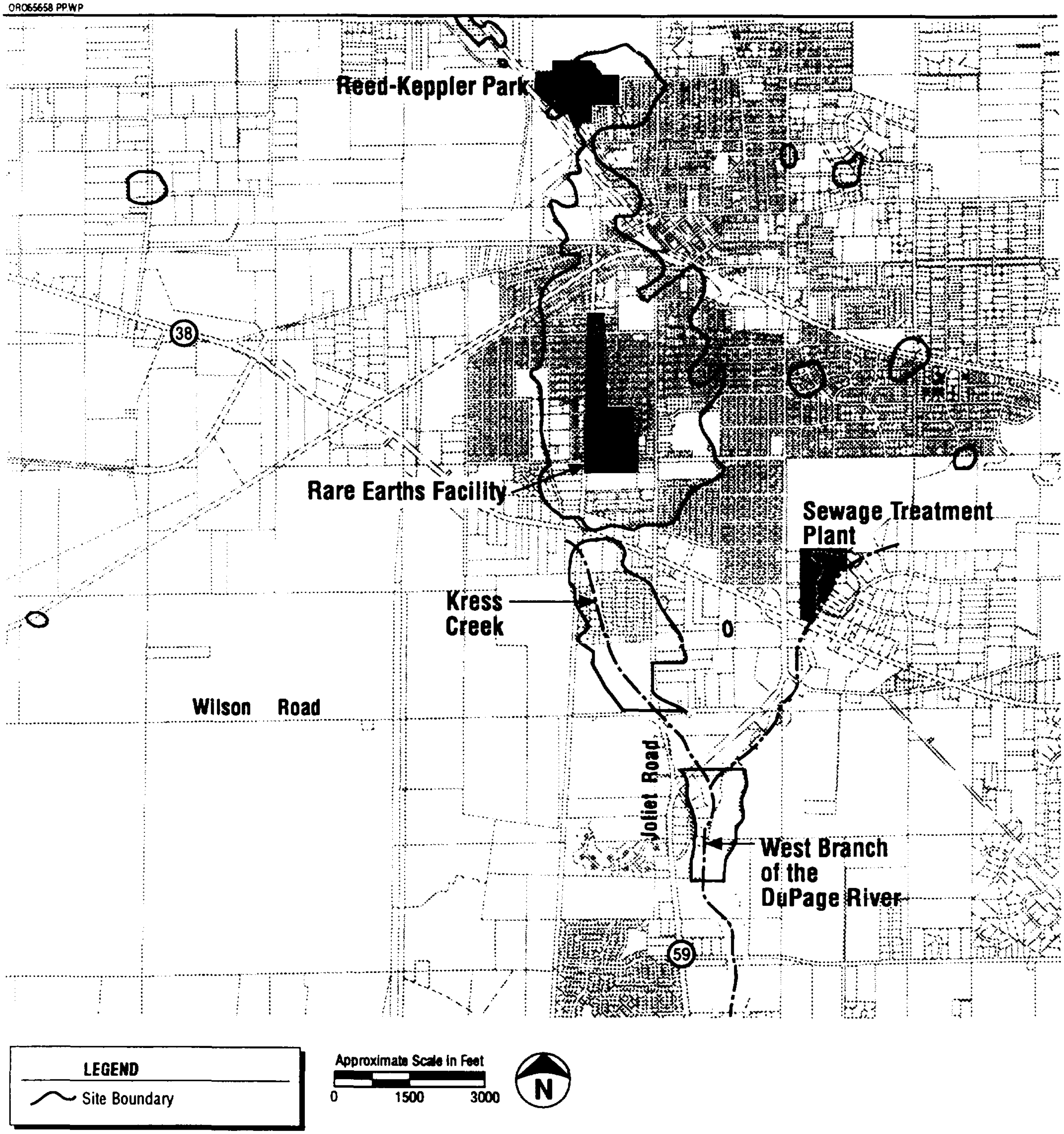


Figure 1-1
Site Map
Residential Areas Site Work Plan

Site Physical Characteristics

Much of the site physical information applicable to the Residential Areas site is taken from a previous remedial investigation of West Chicago sites conducted by EPA (EPA, 1986).

Physiography

The City of West Chicago lies within the Great Lake and Till Plains sections of the central Lowland Provence, about 30 miles west of Lake Michigan. This portion of DuPage County is characterized by gently rolling topography, with greater relief near rivers and creeks. Elevations in this part of the county range from 810 ft north of West Chicago to 700 ft southeast of West Chicago on the West Branch DuPage River. Properties adjacent to the Rare Earths Facility include primarily residential homes and commercial business. Much of the area is open ground; however, asphalt, concrete, and buildings and other structures exist.

Geology

The surficial geology of the region is characterized by glacial drift that was deposited by the Lake Michigan Lobe of a Wisconsinian age glacier. The drift varies in composition from clay tills to gravels and sands. The thickness of glacial sediments ranges from less than 50 ft south of West Chicago to 150 to 200 ft north of West Chicago (Zeizel et al., 1962). The surficial stratigraphy is characterized by generally alternating layers of silts/clays and sands/gravels. At the bottom of the glacial drift is a laterally persistent basal sand comprised of gravel grading upward to sands and silts. Above the basal sand is clay/silt till. Above the till is a well-sorted sand and gravel outwash with some silt and clay. The sand and gravel outwash is laterally discontinuous and may not extend beneath the site. Overlying the outwash, or contiguous with the lower till where the outwash is absent, a poorly sorted clay/silt with some sand and gravel is present. This clayey till is the uppermost unit within the ground (Law Engineering Testing Company, 1981).

The bedrock geology of this region consists of alternating formations of dolomites, shales, sandstones, and siltstones.

Hydrogeology

Four aquifer systems are present in the West Chicago area: the Glacial Drift, the Silurian, the Cambrian-Ordovician, and the Mt. Simon Sandstone. As site investigation activities do not include groundwater quality studies or hydrogeologic investigations because of the unlikelihood that the Residential Areas site has impacted the subsurface (because of the immobility of the contaminants), details on the regional hydrogeology and groundwater use are not included in this work plan. They can be found in the previous RI report (EPA, 1986).

Surface Water Hydrology

The DuPage River, located in northeastern Illinois within the greater Chicago metropolitan region, flows through Cook, DuPage, and Will Counties. The headwaters of the DuPage River consist of two branches, the West Branch DuPage River originating in Cook County and the East Branch originating in DuPage County. The land through which the DuPage River flows is characterized as topographically flat to rolling prairie with some marshy areas in the northern portions of the watershed. The DuPage River is a part of the 1,386 square mile Des Plaines River Drainage Basin as it flows in a southward direction approximately 58 miles (93.5 km) from its origins into the Des Plaines River at Channahon, Illinois.

The West Branch DuPage River, which flows from its origin in Cook County and through DuPage County and portions of Will County, is 28.3 miles long, has an average gradient of 3.7 ft per mile and an approximate drainage area of 380 square miles (Northeastern Illinois Planning Commission, 1978). The West Branch DuPage River flows southward through forest preserve districts, agricultural lands, and urbanized areas toward its junction with the East Branch DuPage River.

Surrounding Land Use

The site area is generally single-family residential housing. The area surrounding the Rare Earths Facility is generally more high-density, single-family residential housing built prior to 1961.

Climatology

The climate of the State of Illinois is typically continental. There are warm summers, cold winters, and frequent periods of temperature, humidity, and wind direction fluctuations caused by easterly migrating weather systems. The West Chicago area, situated about 30 miles west of Lake Michigan, experiences some climate modifications from the lake. The annual average temperature is 48.9°F.

The predominant wind direction is out of the southwest quadrant, and there is a predominance of generally westerly winds. The average wind speed is 11 miles per hour (mph).

Natural Background Radiation

The natural activities of Th-232 in soil in the West Chicago area is about 0.85 picocuries per gram (pCi/g) [Illinois Department of Nuclear Safety (IDNS), June 1993]. Radium-228 in natural conditions is in secular equilibrium with Th-232 and, therefore, background

Ra-228 levels are also approximately 0.85 pCi/g. Background concentrations for Ra-226 are approximately 1.4 pCi/g (Booth et al., 1982). Typical background gamma radiation exposure rates for the West Chicago area vary from about 5 μR/hr to 13 μR/hr (Frigerio et al., 1978; Frame, 1984; Booth et al., 1982; IDNS 1993).

Radon-222 (radon) and radon-220 (thoron), which are noble gas decay products from the U-238 and Th-232 decay chains, respectively, are present under ambient conditions. These gases diffuse or migrate from soil and rock that contain the parent radionuclides and are ubiquitous in homes.

Illinois, and specifically the West Chicago area, are unique because of generally high concentrations of Ra-226 in deep groundwater, which are related to naturally occurring uranium deposits (EPA, 1981). Radium-226 levels in municipal wells screened in the Ironton-Galesville (1,350 to 1,465 ft below land surface) were above background levels in Lake Michigan by one to two orders of magnitude because of natural radium, not because of thorium wastes. These levels were above EPA drinking water standards until the water was diluted with water from shallow wells (Fermi Lab et al., 1981). Private wells screened in the Shallower Silurian Dolomite Aquifer have been found to contain radium, thorium, and uranium levels near regional background levels taken from Lake Michigan (Fermi Lab et al., 1981).

Review of Existing Data

Thorium wastes from the Rare Earths Facility have been found at numerous locations throughout West Chicago and the area outside the City (Frigerio et. al, 1978). These locations are primarily distributed to the east of the Rare Earths Facility, but significant deposits were also evident at properties near Reed-Keppler Park (RKP) and elsewhere (Frigerio et al., 1978; Denny, 1986). Frigerio et. al., 1978, identified 75 deposits in a study conducted from March 1976 to May 1978. The Frigerio study generally covered the city and immediately adjoining areas. Fourteen of the identified locations were outside the city limits.

Kerr-McGee initiated a program in the mid-1980s to survey essentially all properties in the city that might contain thorium residuals. This program detected residuals at 117 locations that exceeded the Kerr-McGee criterion of 30 μR/hr (Denny, 1986). The residuals were generally excavated based on the criterion of 30 μR/hr with several limited exceptions (Denny, 1985; Meldgin, 1986). Contamination at the surveyed locations ranged from windblown material and spillage from trucks to apparent deliberate emplacement of residuals as backfill in yards and under structures.

Kerr-McGee, with assistance from the city, had excavated (by the end of 1985) thorium residuals from 116 of the 117 identified locations within the city. However, in some instances, some contaminated materials were left in place. Those instances include residuals left under foundations at a few properties; several properties that may not contain residuals but where permission to survey the property for residuals was not given; a location where a small amount of material is associated with the support walls for a swimming pool; a property where permission was not granted for removal of material from a backyard; and the Bolles Opera House at 185 West Washington (former laboratory and marketing facility) (Denny, 1985; Meldgin, 1986).

In 1989, EG&G conducted a second aerial radiological survey of West Chicago for IDNS (the first aerial survey was conducted in 1977 and was part of the 1978 Frigerio Report). This survey, including ground level verification surveys conducted by IDNS, identified 50 additional properties with elevated gamma radiation.

The State of Illinois petitioned the NRC for amendment of the agreement state licensing program to include licensing control of the material at the Rare Earths Facility. IDNS was granted licensing authority effective November 1, 1990. During the spring of 1990, in preparation for gaining licensing control, IDNS expanded its environmental monitoring program in and around West Chicago. This expansion included outdoor Rn/Tn and air particulate evaluations at several of the local schools.

A preliminary focused risk assessment was conducted and developed by U.S. EPA to specifically address three school properties and four residences identified and sampled by IDNS to determine the potential existing and future risk and to compare it with the risk caused by placing the contaminated soil in a temporary storage location. Data used in the preliminary focused risk assessment shows Th-232 activity at the schools varying from 3 to 30 pCi/g. Radium-228 activities at residences included in the preliminary focused risk assessment ranged from 28 to 780 pCi/g.

Approach Overview

The current system for Superfund cleanups is based on two programs, remedial and removal. The remedial program is traditionally geared toward long-term remedies, often addressing risks with more significant future components. These remedies are usually more expensive and, as such, the evaluation of alternatives is often more extensive. The removal program has traditionally been used to clean up immediate risk threats, both those requiring immediate attention (time critical removals) and those that, even with some immediate risk, can afford some planning activities (non-time critical removals). The NCP poses both cost and time limits on removal action. The 2-year/$2 million statutory limit restrictions are for fund-lead projects only. However, even for fund-lead actions, EPA can get waivers from the time and cost limitations for certain situations. These limits are not in effect if PRPs do the work. Because of lower costs and more immediate, focused risks, the site characterization and alternatives evaluation phase of the action is also more focused. This focus can save time and money over a traditional remedial documentation approach.

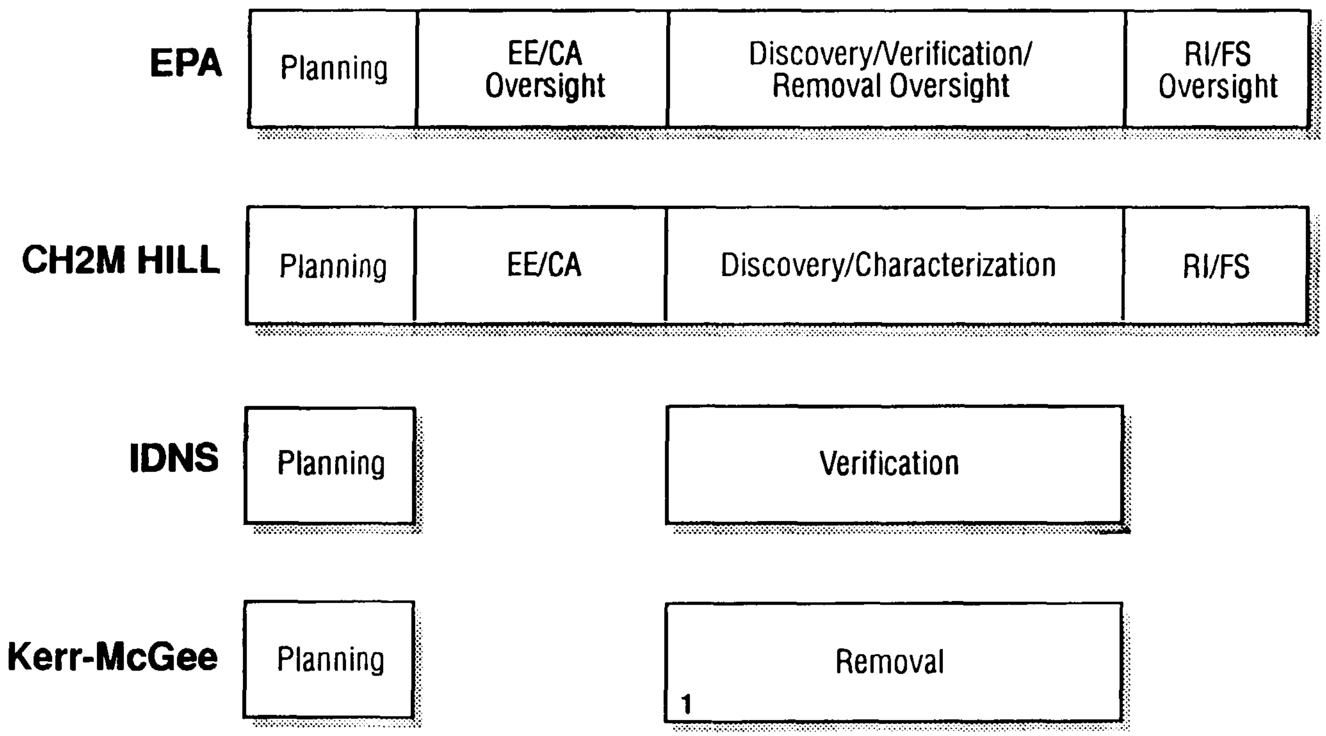
Flexibility in the program is being encouraged by EPA Headquarters through the new Superfund Accelerated Cleanup Model (SACM). SACM encourages early actions, such as non-time critical removal actions, to be taken at sites. This allows focused actions that reduce risk to be taken sooner at sites that already have been characterized and for which remedial alternatives are known or are limited. This concept of expedited removals to mitigate risk is being applied to the Residential Areas site in West Chicago. Following the non-time critical removal, a final RI/FS will be conducted to determine if additional action is warranted.

An inherent assumption in the Superfund processes is that more study will progressively reduce, by meaningful amounts, the uncertainty in site conditions and technology performance. For all but the simplest waste sites, the marginal value of collecting and analyzing the next sample declines rapidly once general site conditions are ascertained. Because of the basic complexity of a hazardous waste site and its associated uncertainties, engineers inevitably enter the implementation phase with many unresolved questions. Volume of contaminated material is the major uncertainty in the instance of the removal action at the Residential Areas site.

This uncertainty need not hamper the project either by being ignored or by suspending operations until the uncertainty is removed. The approach presented in this work plan is to collect data during the implementation of the removal to resolve the remaining uncertainties. A discovery phase (supplemented by a characterization phase in areas of conflicting or inconclusive results) of data collection will be used to determine the areal extent of contamination, while a verification phase of data collection will determine the depth of contamination by verifying when excavation can stop.

Following the removal action, a final RI/FS will be conducted at the site to determine if further remediation is necessary. The decision of further remediation will be heavily based on a residual risk assessment that will be conducted on the sites. Therefore, data to support the residual risk assessment will need to be collected prior to the RI/FS. The approach taken in this project is to collect the data to support the RI/FS also during the removal to avoid another sampling event.

Many government agencies and companies are involved in this project. The discovery and characterization phases of the removal as well as subsequent remedial activities (i.e., RI/FS) are EPA fund-lead projects. For the purpose of preparing this work plan, it is assumed that through EPA's negotiations with Kerr-McGee, Kerr-McGee will conduct the actual removal actions (excavations) in the field. CH2M HILL will support EPA by developing the EE/CA, conducting the discovery and characterization phases of data collection, and conducting the final RI/FS. IDNS will provide support by conducting the verification phase of data collection. The RI/FS will be based on data from both phases. Figure 1-2 illustrates the various activities and the responsible group. Communication and cooperation between the groups are essential to successful completion of the project. To provide data communication, IDNS and CH2M HILL will use essentially the same database system. This allows continual interaction between the groups to meet EPA and IDNS needs, for the removal and RI/FS and for other activities such as community relations.



1 *For project planning purposes, it is assumed that Kerr-McGee will be conducting the removal activities.*

Figure 1-2
Roles and Responsibilities
Residential Areas Site Work Plan

Data Needs Evaluation

Conceptual Site Model

The current conceptual site model (Figure 1-3) is a framework within which the environmental pathways of potential concern are identified and illustrated. The media to sample for determining whether a release has occurred can be identified from the model. The model also serves as the framework for conceptualizing general response actions.

The model includes a set of hypotheses about the contaminated media and environmental pathways that are selected on the basis of existing data. The source areas are typically identified as those areas of direct waste deposition. For the focus of the removal and remedial actions pertaining to the Residential Areas site, the secondary source of contaminated soil becomes the primary source. Though not shown on the model, the source of the contamination in the soil is the Rare Earths Facility, either as a result of tailings used as backfill or from wind blowing the material off the facility.

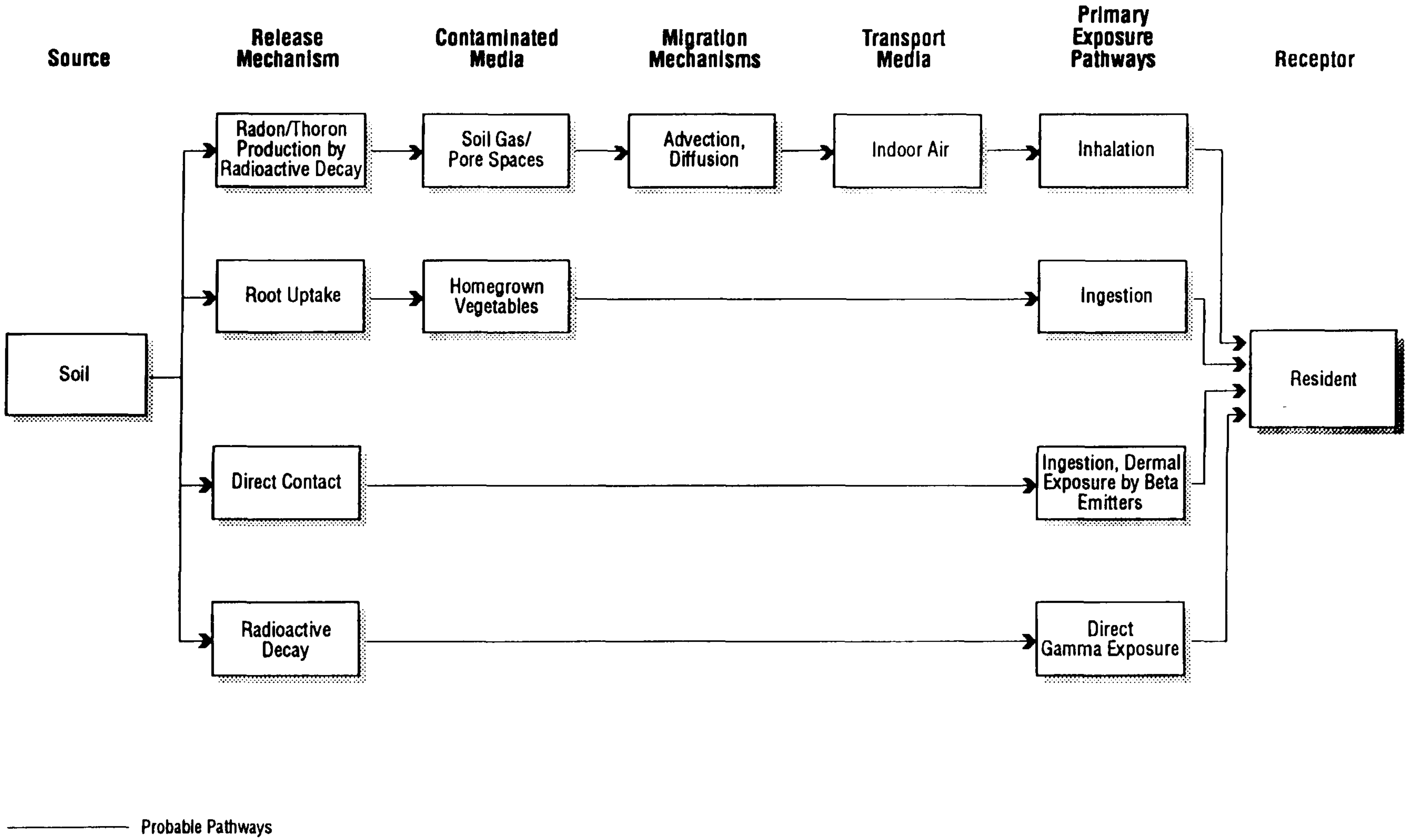
A contaminant release mechanism is defined as any process that results in migration of a contaminant from a source area into the immediate environment. Once in the environment, contaminants can be transferred between media and transported away from the site.

The conceptual site model illustrates the various media, transport pathways, and exposure pathways that could be affected as a result of the residential soil contamination. Although this is specified as a model of current conditions, future conditions under a no action scenario are expected to be similar. The land use is not expected to change in the future and because the soil has been contaminated for up to 40 years, no new release mechanisms are expected in the future.

Radionuclide contamination of residential soils has been shown by data collected during previous investigations. The most likely contaminants include Ra-226 and Ra-228 and their decay products. Other elements of the U-238 and Th-232 decay chains are expected present in amounts equal to or less than Ra-226 and Ra-228.

Other potential contaminants of concern are lead, barium, and chromium. These metals were detected in samples collected from the Rare Earths Facility at levels above those found in background samples collected from RKP and STP during the 1993 RIs.

The conceptual site model includes four release mechanisms for contaminants: (1) Gas production and release by molecular diffusion and advection. Radon and thoron can be produced as a result of radioactive decay in the contaminated soil and then released into the soil pore spaces and then to indoor air. (2) Root uptake. Vegetables grown in the contaminated soil can uptake radionuclides into their mass. (3) Direct contact. The presence of the contamination in residential areas allows direct access to the contaminants without any release mechanism. (4) Radioactive decay. In addition to production of Rn and Tn, radioactive decay of Ra-226 and Ra-228 results in gamma radiation. Gamma



Potential contaminants of concern: Th-232 and U-238 and daughters, Lead, Barium, Chromium

Figure 1-3
Current Conceptual Site Model
Residential Areas Site Work Plan

radiation can be released from the soil and affect the residents. These release mechanisms allow for direct contact with the contaminants by the residents. However, they probably do not cause contamination of additional media.

Release mechanisms that are not considered to be reasonable are erosion and leaching. Erosion resulting from surface water or wind has already occurred and has resulted in the contamination of soil that is considered part of the site. Further erosion is not likely because of the flat topography and vegetated or concrete covers over most of the contamination and therefore is not included in the model. The low mobility of the contaminants and the surface deposition of much of the contamination means that leaching of contaminants at levels that would cause contamination of the underlying groundwater is unlikely. Additionally, split samples analyzed by IDNS from groundwater samples collected at the RKP site during the 1993 remedial investigation showed no evidence of other than naturally occurring radioactivity. Therefore leaching is not included in the model.

Diffusion and advection of Rn/Tn is the only potential migration pathway. Radon and thoron can migrate both outdoors and indoors through cracks in the foundation. Only indoor accumulation is considered a potential concern because of the possibility of accumulation of the radon to unacceptable levels in closed spaces.

The exposure potential to these potentially contaminated media is discussed in the next section, Preliminary Risk Assessment.

Preliminary Risk Assessment

This preliminary risk assessment is based on existing data and uses results from a preliminary focused risk assessment conducted by EPA (EPA, 1993) for exposures to radioactive constituents in the soil. The preliminary risk assessment presented in this work plan is a qualitative evaluation of the actual or potential risks to human health from exposure to radioactive contaminants in the soil at residential properties under a no further action scenario. The intent is to identify data needs to support subsequent baseline risk assessment efforts. This assessment assists in identifying media and analytes of probable and potential concern.

The steps used to conduct the preliminary risk assessment are as follows:

- Identify an initial list of contaminants of concern.
- Identify the potential exposure pathways.
- Identify potential human receptors of concern.

An ecological preliminary risk assessment has not been included. Within the project boundaries, land use is predominantly residential. As a result, potential wildlife habitat is restricted. Wildlife existing within these areas is expected to be composed of common edge species, with a lower abundance and diversity than less developed lands. Habitat factors within residential areas, such as the maintenance of grassy lawns, abrupt edges, pets, and human disturbances, are expected to limit wildlife presence. These factors are also expected to limit the potential for exposure to wildlife that is present by lessening the possibility for direct ground exposure to gamma radiation. Direct exposure to some ground-feeding species, as well as the potential for exposure through the food chain, may exist for some wildlife. However, the total number of species potentially affected is considered small. Affects to aquatic environments are being addressed under another site, the Kress Creek site.

Contaminants of Concern

Contaminants of concern are defined as those most likely to contribute to risk as a result of exposure. Several factors are considered in developing this set of contaminants for a residual risk assessment. However, for this preliminary effort, contaminants identified as being present at the Residential Areas site (Th-232 and U-238 and daughter products) are considered as probable contaminants of concern. The discovery criteria described later are based on total radium in the soil (Ra-226 plus Ra-228). Radium is one of the few daughter products of Th-232 or U-238 that has a cleanup standard in soil in various state and federal regulations. However, because the daughter products are in equilibrium at this site, radium activities are excellent indicators of the presence of U-238, Th-232, and other daughter products. The actinium series radionuclides (U-235 and its decay products) are not considered contaminants of concern for this site. The actinium series radionuclides are not expected to be present except in concentrations much less than the thorium and uranium series radionuclides. In addition, the primary exposure route of concern for these radionuclides is through inhalation of contaminated dust. The dust inhalation pathway is not a significant pathway at this site because the residential areas are heavily vegetated. Thus the actinium series radionuclides should pose negligible risk in comparison to the thorium and uranium series radionuclides.

Other potential contaminants of concern are lead, barium, and chromium. These metals are considered contaminants of concern due to the fact that they were detected at the Rare Earths Facility at above background concentrations when compared to background samples collected at RKP and the West Chicago STP. These metals are presumed to be commingled with the radionuclide contamination at the residential properties as a result of Rare Earths Facility processes. The correlation of concentrations of lead, barium, and chromium to concentrations of radionuclides will be evaluated during the pilot study. Assuming that a correlation exists at low radionuclide concentrations (less than 5 pCi/g), metals concentrations are expected to be at levels not likely to cause adverse health effects (less than risk-based soil concentrations). However, at high radionuclide concentrations (and high metals concentrations), lead, barium, and chromium will be removed along with soils in which radionuclide concentrations exceed 5 pCi/g. Therefore, the presence of these metals becomes mainly a waste disposal issue. However, these metals will be evaluated with regard to potential residual risks from the low levels remaining.

Below is a brief discussion of the toxicological effects of the contaminants of concern initially identified. General hazards of radiation exposure are described first, followed by a discussion of specific characteristics of the two decay chains (Th-232 and U-238) that contain the contaminants of concern. Toxicological properties of the nonradiological contaminants, lead, barium, and chromium are also included. The list of contaminants of concern will be reassessed during any residual risk assessment activities.

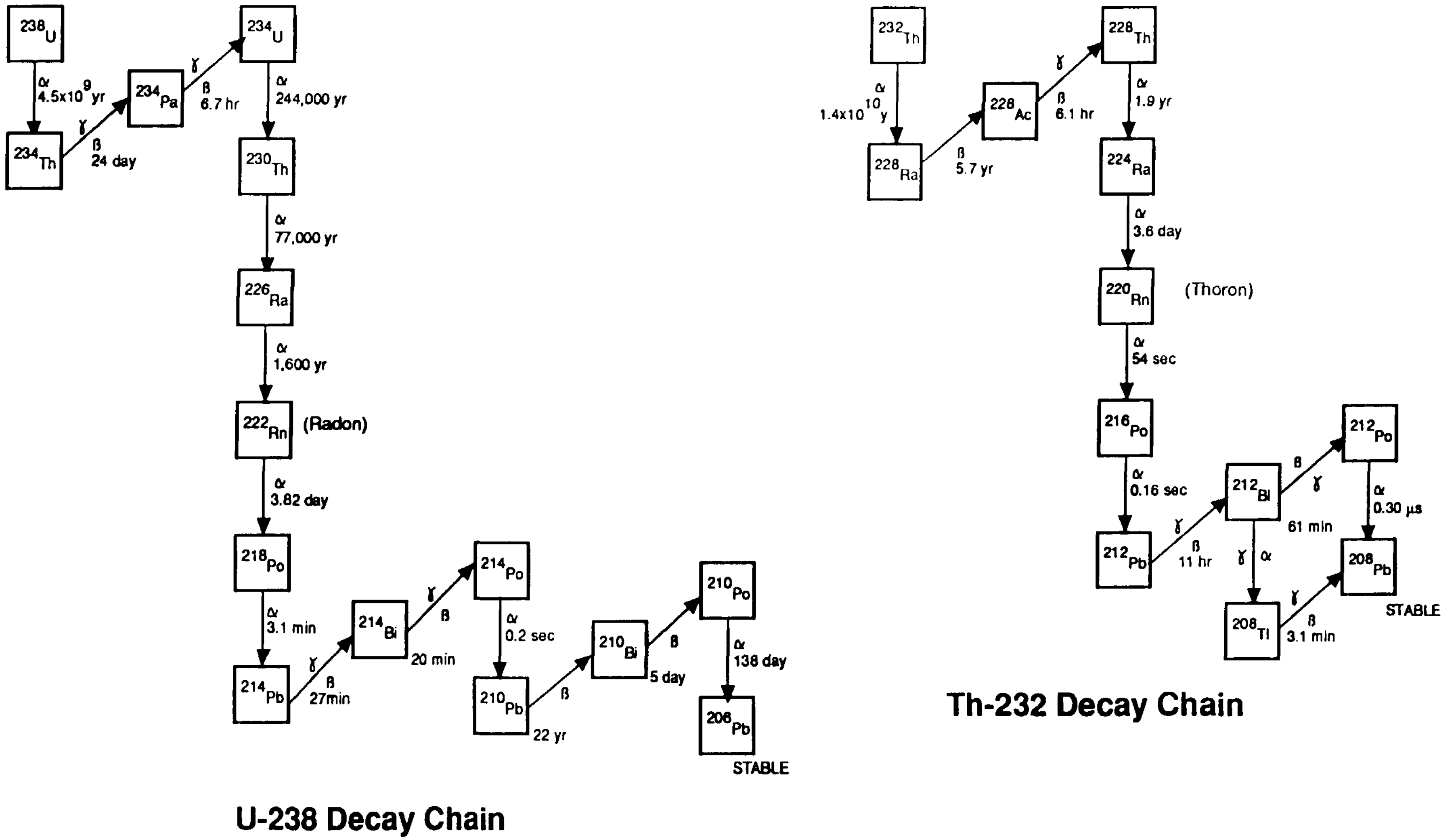
The effects of exposure to ionizing radiation from all of the radionuclides of concern fall into three general categories: carcinogenic, genetic, and teratogenic. Radiation produces damage in biological systems through ionization of molecules. Damage may occur directly, as when a chromosome breaks into smaller pieces after absorption of energy from radiation. Damage may also occur indirectly, through ionization of water molecules, to produce highly reactive free radicals. The free radicals may react with other cellular compounds and cause damage through oxidation reactions. For this assessment, the potential for cancer induction in the exposed individual is considered to have the most significant effect on health. Risks of genetic effects from radiation exposure or of fetal (teratogenic) effects are considered less significant. These assumptions are consistent with the current understanding of the effects of radiation. A more detailed evaluation of the effects of exposure to radiation will be provided in the toxicity assessment of the residual risk assessment for the Residential Areas site.

Ionizing radiation is a demonstrated human and animal carcinogen. Data exist that correlate high exposures of radiation to cancer induction in humans. In general, scientists agree that the probability of cancer increases with dose, but the dose-response model that predicts the effects of low-level exposure is still under debate. Current radiation protection standards are based on the idea that each increment of radiation exposure causes a linear increase in the risk of cancer. Significant uncertainty exists from extrapolating high-level information to low-level effects, but the models used are generally believed to be conservative (i.e., they will overestimate risks).

Thorium-232. Thorium-232 decays through Ra-228, Ac-228, Th-228, and Ra-224 to Rn-220, which is a noble gas with properties similar to Rn-222 (see Figure 1-4). Historically, Rn-220 has been called thoron (derived from its parent, thorium), and the term is used to minimize confusion with the isotope Rn-222, often referred to simply as radon. Uranium and radium are generally more mobile in the environment than thorium. Thorium is relatively insoluble in water at environmental pHs (neutral) and has a low uptake in plants.

The gamma photon decay energies and the number of photons emitted are greater for the Th-232 chain than for the U-238 chain. Hence, the gamma exposure rate per unit of activity for Th-232 is greater than for U-238. Lead-212 is a daughter product of Th-232. It has a lower adverse health risk in the lung (EPA, 1986) than radon decay products because of its primary mode of decay (beta) and its relatively long half-life. Many of the thorium series radionuclides decay by beta particle emission. Skin doses from beta radiation may be possible if thorium series decay product contamination is present in soils on exposed skin surfaces.

Uranium-238. The uranium isotopes emit alpha particles; some uranium decay products also emit alpha particles. Alpha radiation is primarily an internal exposure hazard because



NOTE:

Times shown are radioactive half-lives for each radionuclide

- α = primary mode of decay is alpha emissions
- β = primary mode of decay is beta emissions
- γ = gamma emissions included only for significant γ emitters

Figure 1-4
Radionuclide Decay Chains
Residential Areas Site Work Plan

of its rapid energy dissipation over a short distance. The organs of most concern, as a result of uranium ingestion or inhalation, are the kidneys and bones. In addition to hazards from exposure to alpha radiation, uranium is chemically toxic to the kidneys.

Uranium-238 decays through Th-234, Pa-234, U-234, and Th-230 to Ra-226, which is the parent of Rn-222. Radon-222 is a noble gas that may diffuse or migrate through pore spaces to the ground surface and then be transported by the atmosphere. The release of radon and subsequent decay products results in a potentially significant source of lung exposure—often referred to as radon decay product exposure. Radon-222 decays to Po-218, Pb-214, etc. (see Figure 1-4), which are particulate, short-lived decay products. The most significant portion of lung exposure from inhalation of radon results from the alpha energy deposited in lung tissue by these short-lived decay products. In addition to lung exposure from radon decay products, uranium decay products also emit beta and gamma radiation. Gamma radiation exposes the entire body rather than a specific organ. As with thorium series beta emitters, skin doses may be possible if uranium series decay product contamination from soils is present on exposed skin surfaces.

Lead. Lead is a ubiquitous, naturally occurring metal. Infants and young children are the most vulnerable populations that may be exposed to lead and are the focus of EPA's risk assessment efforts for this metal. Elevated levels of lead have been associated with increased risks of potential adverse effects on neurological development and diverse physiological functions, such as hematologic effects and neonatal effects.

Lead is also classified as a B2 carcinogen (probable human carcinogen). However, no toxicity value is currently available for the carcinogenic effect.

Barium. Barium is present naturally in the environment. Its industrial use is primarily in various metal alloys, paints, and other products. Exposure to barium may be via ingestion and inhalation of contaminated dust particles. The toxicity of barium compounds depends on their solubility. Compounds such as barium salts are relatively soluble, and ingestion can cause paralysis, cardiovascular abnormalities, and gastroenteritis. Prolonged inhalation of barium has resulted in baritosis, a benign, reversible pneumonia-like disease, found primarily in exposed workers.

Chromium. Chromium is potentially present in the hexavalent or trivalent forms. Of these, the hexavalent form is more toxic and mobile. Risks associated with chromium are conservatively evaluated using the assumption that all reported chromium is in the more toxic hexavalent form.

Potential Exposure Pathways

An exposure pathway consists of three elements:

- A source of contamination and release mechanism
- A point of potential receptor contact with the contaminant
- A route of exposure

Exposure pathways may also require a contaminant transport mechanism if no receptors exist at the source of contamination. At the Residential Areas site, contaminant transport is not necessary because the soil of the residences is contaminated.

The conceptual site model (Figure 1-3) illustrates the completed primary pathways for current and future conditions. The most probable completed pathways that could result in exposure are anticipated as follows:

- Direct gamma exposure to human receptors resulting from radioactive decay from contaminated soil

- Incidental ingestion of contaminated soil by human receptors

- Human inhalation of Rn/Tn and decay products emanating from contaminated material

Other potential exposure pathways, although less likely to be completed include the following:

- Human ingestion of contaminated vegetables

    - Information regarding this pathway (e.g., frequency of gardening, type) will be gathered during the Populations Survey to assess the potential impact to overall risk. Published data regarding plant uptake of radionuclides from soil will be used in evaluating exposures from this pathway.

- Dermal exposures to beta emitters from contaminated soils on exposed skin surfaces

    - This pathway will be addressed initially through a screening evaluation using conservative assumptions and comparing the results to total risk from the other exposure pathways.

Potential Receptor

The resident receptor, including adults and children, would be considered the most important receptor under reasonable maximum exposure scenarios and would be used to determine if action is warranted. An intermittent-type receptor, such as a trespasser, is therefore not considered. The potential for exposure and risk to future receptors is considered to be the same as for current receptors because the land use is not anticipated to change. The Preliminary Focused Risk Assessment conducted by EPA estimated total maximum residential risks for the properties that were surveyed under current land uses at 3×10^{-4} to 3×10^{-3}. These risks are primarily a result of direct gamma exposure and indoor Rn/Tn progeny exposure. These risks could be overestimated because they are based on modeled Rn/Tn concentration data using the maximum Th-232 activity at a property and maximum measured net gamma exposure rates rather than measured Rn/Tn progeny concentrations or average gamma dose rates. Secondary risk exposure pathways in that assessment included soil ingestion, vegetation ingestion, and inhalation of contaminated dust.

The conceptual site model and the preliminary risk assessment discussed in this section highlighted the following points key to collecting data:

- The primary release mechanism is direct gamma emissions which are directly measurable. Rn and Tn emissions are potential release mechanisms that will be measured through indoor air monitoring. Another release mechanism is direct contact, which is measured by radionuclide analysis. These release pathways are the focus of the removal action.

- Vegetative uptake will be modeled using soil radionuclide analysis. Although this pathway is assumed to be remediated through the removal action, it will be further investigated during the RI/FS to assess the risk that remains after removal.

- Inhalation of contaminated dust contributed a maximum risk of 4×10^{-8} under conservative exposure scenarios presented in the Preliminary Focused Risk Assessment. Because dust inhalation contributed only approximately 0.01 percent of the risk in this assessment, and because the residential areas site is heavily vegetated, this pathway will not be considered further for residential exposures.

- Dermal exposures to beta emitters in soil are considered a low potential exposure pathway. This pathway was not evaluated in the preliminary focused risk assessment. However, a screening evaluation of dermal exposure to beta emitting radionuclides will be conducted as part of the residual risk assessment using upper bound exposure parameters. If risks are negligible under upper bound assumptions, dermal exposures will not be evaluated for all scenarios.

- The contaminants of concern are U-238 and Th-232 and their daughter products (most notably Ra-226 and Ra-228). Based on results of previous investigations, it is assumed that the uranium and thorium decay series are in equilibrium at this site. Additionally, the possibility of lead, barium, and chromium as contaminants of concern will be investigated through metal analysis to support the final residual risk assessment.

The uncertainties for the final RI/FS addressed by collecting data during the discovery phase are presented in Table 1-1.

Table 1-1 RI/FS Site Condition Uncertainties and Data Needs		
Media	**Uncertainty**	**Data Needs**
Soils	Different cleanup level than removal action for final action.	Radionuclide data on residences not remediated during removal that have potential to exceed background and on areas remediated during verification to support residual risk assessment. Gamma dose rates also used to support risk assessment.
	Presence of lead, barium, and chromium as contaminants of concern.	Lead, barium, and chromium analysis during discovery.
Air	Risk from radon.	Indoor air monitoring (after removal and at sites not identified for removal).
Biota	Risk from vegetative uptake.	Surface soil analysis to support residual risk assessment.

Preliminary Identification of Remedial Action Technologies

Potential response actions and technologies for remediating the soil were developed to identify data needs for this work plan. Identification of these measures is preliminary as an aid to define investigative needs and not intended as a substitute for the more detailed process of technology screening during the EE/CA or FS. These technologies were selected to meet potential remedial action objectives. These objectives are based on the preliminary identification of applicable or relevant and appropriate requirements (ARARs) and other guidance.

Preliminary Applicable or Relevant and Appropriate Requirements

The NCP specifies, at 40 CFR 300.430(f)(1)(ii)(B), that "On-site remedial actions selected in a Record of Decision (ROD) must attain those ARARs that are identified at the time of ROD signature or provide grounds for invoking a waiver. . ." Although a waiver can be obtained for an action that is considered an interim action and it is stated that the final action will achieve ARARs, the NCP also states that "Fund-financed removal actions under CERCLA section 104 and removal actions pursuant to CERCLA section 106 shall, to the extent practicable considering the exigencies of the situation, attain applicable or relevant and appropriate requirements under federal environmental or state environmental or facility siting laws. . . In determining whether compliance with ARARs is practicable, the lead agency may consider appropriate factors, including: (1) The urgency of the situation; and (2) The scope of the removal action to be conducted." (Section 400.415(i)).

Applicable requirements are ". . .those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site" (52 FR 32496, August 27, 1987).

Relevant and appropriate requirements are ". . .those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a. . . CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (52 FR 32496, August 27, 1987).

The EPA Office of Solid Waste and Emergency Response (OSWER) Directive No. 9234.0-05 identified three types of ARARs:

- Contaminant-specific
- Location-specific
- Action-specific

Contaminant-specific ARARs set limits on concentrations of specific hazardous substances, pollutants, and contaminants in the designated media. Examples include drinking water standards and ambient air quality standards. Location-specific ARARs set restrictions on activities in certain types of areas such as wetlands, floodplains, or historic sites. Action-specific ARARs set controls or restrictions on particular kinds of activities that are triggered by the specific type of remedial action under consideration. For example, the Clean Water Act (CWA) includes regulations for treated water discharge to navigable waters. Action-specific ARARs will be presented in the EE/CA and the FS once alternatives are identified.

The following sources of ARARs have been identified by EPA for cleanup actions at the residential sites.

<u>Title 40, Part 192 of the Code of Federal Regulations (40 CFR 192), entitled "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings"</u>—These regulations contain EPA standards for cleanup of lands contaminated by uranium and thorium mill wastes. The regulations apply only to the sites specifically designated under the Uranium Mill Tailings Radiation Control Act of 1978, but they often have been used as criteria at uranium, thorium, and radium sites because of the similarity of the problems. They are not considered applicable to the site, but portions are considered relevant and appropriate.

<u>Title 32, Chapter II, Subchapter b, Part 332 of the Illinois Administrative Code, entitled "Licensing Requirements for Source Material Milling Facilities"</u>—These regulations deal with licensing requirements for source material milling facilities in Illinois and apply to the Kerr-McGee Rare Earths Facility in West Chicago. They are not applicable to the Residential Areas site, but portions are considered relevant and appropriate.

<u>Title 32, Chapter II, Subchapter b, Part 340 of the Illinois Administrative Code, entitled "Standards for Protection Against Radiation"</u>—These regulations establish standards for protection against radiation hazards, primarily in an occupational setting. They control the possession, use, and transfer of sources of radiation by "licensees and registrants" so that the total dose to an individual does not exceed specified standards. They also contain decontamination guides for the release of equipment for unrestricted use. These regulations are not applicable to the site, but portions are considered relevant and appropriate.

<u>DOE Order 5400.5 entitled "Radiation Protection of the Public and the Environment"</u>—This order establishes standards and requirements for the Department of Energy (DOE) operations with respect to protection of members of the public against undue risk from radiation. The order is not a promulgated Federal or State regulation, and thus cannot be an ARAR, but portions of it are to be considered (TBC).

<u>Title 10, Part 20 of the Code of Federal Regulations (10 CFR 20), entitled "Standards for Protection Against Radiation"</u>—These regulations contain the Nuclear Regulatory Commission's standards for protection against radiation, and contain an as low as

reasonably achievable (ALARA) approach. They are not applicable or relevant and appropriate to the Residential Areas site, but portions can be considered to be TBCs.

U.S. Nuclear Regulatory Commission's Regulatory Guide 8.37—This regulatory guide contains, among other things, a discussion of the NRC's ALARA approach. The regulatory guide is not a promulgated regulation, and thus cannot be an ARAR, but a portion can be considered to be a TBC.

U.S. Nuclear Regulatory Commission's Regulatory Guide 1.86—This regulatory guide contains, among other things, decontamination guides for the release of equipment for unrestricted use. The regulatory guide is not a promulgated regulation, and thus cannot be an ARAR, but a portion can be considered to be a TBC.

Preliminary Remedial Action Objectives

Preliminary remedial action objectives for both the removal action and for the final remedial action have been identified to provide a framework for identifying potential technologies. The objective of the removal action is to remove sufficient contaminated soil to protect human health against exposure to the contaminants of concern. It is assumed that soil that is posing a risk to human health will have a surface expression of contamination or will result in elevated levels of gamma rays or radon in the house.

A variety of potential risk-based and ARAR-based cleanup levels has been evaluated. To this point, considering residual risk and ARARs, a discovery and cleanup level not to exceed 5 pCi/g total radium above background is EPA's remedial action objective. (Averaging of values over area will not be considered in identifying sites for remediation, but averaging over area may be considered for determining when enough removal has occurred.) This level is based on the federal and state ARARs for mill tailings and primarily considers direct emission and radon inhalation risks. Combined with this cleanup level is the principle of ALARA, which is also established by federal and state ARARs for radiation protection. Once an area has been discovered based on the 5 pCi/g level above background, as much soil as reasonable will be removed. In many instances, especially for small areas contaminated on the surface, all contamination above background may be removed. More information on the cleanup level and ALARA will be provided in the EE/CA.

The remedial action objective for the final action is to control current and future risks by all reasonable exposure pathways. If the assumption that buried contaminated soil has a surface expression is valid and if exposure pathways remaining after the removal action do not result in an unacceptable human health risk, the final remedial action at the Residential Areas site may be no further action.

Technology Descriptions

Contaminated soils are anticipated to be remediated during the removal action and possibly during the final action, because the primary objective is to remove unacceptable levels of contamination from the residential properties. Because containment in place is not an acceptable alternative for residential sites, only removal, treatment, and offsite disposal technologies are discussed.

Identified removal technologies include excavation with standard earth moving equipment. Erosion control during excavation and air emission controls may be needed. The Rare Earths Facility is assumed to be the area designated for the handling, processing, treatment, and loadout for offsite disposal of excavated material.

Potential treatment technologies for radioactive soils are limited. Studies have shown that physical separation can be used to achieve residual soil activities of 10 to 15 pCi/g (Richardson and SC&A, Inc., 1989). The additional steps of soil washing or chemical extraction do not significantly reduce the residual activity levels in the soil. Pilot treatability studies would be necessary before the effectiveness of the treatment technologies on the residential site soil could be assessed. The purpose of volume reduction is to reduce disposal costs when significant volumes of contaminated material are to be disposed of.

Currently only one potential offsite disposal option is available to accept by-product material as defined by paragraph 11 (e)(2) of the Atomic Energy Act—Envirocare in Utah. The facility has received its license from NRC to allow acceptance of 11 (e)(2) material, but has conditions attached to the license that the facility is addressing. If delays are encountered with the facility in resolving in these conditions to their license, material removed from residences will be stored in an interim facility until shipment to the Utah facility.

Table 1-2 contains two uncertainties associated with potential final remediation technologies that serve as a basis for data collection. Uncertainties on technology performance for the removal are managed during the removal.

Project Summary

The purposes of this project are to document the removal decision, conduct the removal, and select a final remedy for the site. Most of the activities in this work plan center on removing the remaining site condition uncertainties during the removal action. Removals can begin after the EE/CA is approved. In order to determine locations that meet removal action criteria, a discovery and characterization phase of investigation will occur. This investigation will be conducted by CH2M HILL under contract to EPA. As the removals are completed at each location, IDNS will conduct a verification phase of investigation to verify that all contamination exceeding the verification criteria has been removed.

Table 1-2
RI/FS Technology Uncertainties and Data Needs

Technology	Uncertainity	Data Needs
Excavation to various action levels	Unknown volume.	Area of contamination determined by radiological walkover and sampling and analysis.
Disposal	Excavated material meets Envirocare waste acceptance criteria.	Radiological characterization.

EPA has taken a conservative approach in establishing the discovery criteria in order to minimize the chances of not discovering properties where contamination is present. The discovery criteria are slightly more stringent than the verification criteria in that for outdoor soil concentrations, discovery results will not be averaged over 100 m^2. However, verification results may be averaged. The discovery criteria are as follows:

- Outdoor soil activity concentration. Five pCi/g total radium (Ra-226 plus Ra-228), dry soil, above background in any 15 cm depth

- Outdoor gamma exposure rates. Statistical exceedance of background

- Indoor gamma exposure rates. Statistical exceedance of background

- Indoor Radon/Thoron decay product. 0.02 WL combined Rn and Tn decay products (including background)

The criterion for outdoor soil activities is the primary one that will trigger removal; the other three criteria are finding tools to assist in determining if contamination could be present. The way these criteria are used to determine the need for removal is discussed below.

The project activities during the discovery and characterization phase of the investigation are designed to provide the maximum amount of information as required by EPA as efficiently as possible. Although the discovery criteria are specified for radionuclide-specific activities in soil, indoor and outdoor exposure rates, and indoor Rn levels, the use of other monitoring technologies is being proposed to expedite the collection of information. For instance, outdoor gamma scan information can be gathered over 100 percent of the area and can be statistically correlated to potential radionuclide levels in the soil. Regardless of the amount of time allowed, 100 percent coverage could not be obtained through intrusive sampling.

To determine the specific use and limitations of various monitoring tools, a pilot study will be conducted before the discovery and characterization phase of investigation. Among the purposes of the pilot study are as follows:

- Correlation of gamma scan results with background levels or very high levels of radionuclide-specific soil activity

- Correlation of in-situ gamma spectroscopy results with laboratory analytical results

- Correlation of elevated gamma activity to elevated lead, chromium, and barium levels

- Determine the limitations of gamma scan survey results in areas of potential elevated radiation levels because of scattered gamma radiation (shine) from the Rare Earths Facility

- Quantification of background (naturally occurring) soil conditions

The indoor air and gamma measurements task will start prior to the pilot study and will continue over the 2-year field effort. This task will be separated into several phases. The first phase (Phase I) will occur during the winter of 1994 and will be smaller than the other phases. In addition to collecting indoor gamma exposure rates and Rn/Tn values, this phase will attempt to establish characteristics of naturally occurring Rn/Tn and indoor gamma survey results.

The discovery and characterization phases of the investigation will begin once the necessary correlations and information from the pilot study and Phase I air monitoring are collected. Information from the studies will be periodically summarized and evaluated and submitted to EPA for a removal decision on the areas investigated. Initial discovery surveys at every property will consist of three types of measurements: (1) outdoor gamma scan for evaluating surface soil contamination, (2) indoor Rn/Tn decay product measurements for evaluation of indoor air contamination and potential for subsurface tailing deposits, and (3) indoor gamma measurements for evaluation of tailing deposits near foundations.

If the results of all three measurements indicate no contamination (as defined by the discovery criteria set by EPA and using correlations established in the pilot study), the property may be a candidate for no removal. If a very strong statistical correlation of gamma scan results with soil sample results can be established during the pilot study, and if this correlation is tested and demonstrated repeatedly during field activities, then it is possible that a property may be designated as a candidate for no removal based on outdoor gamma scan results, indoor Rn/Tn delay product measurements, and indoor gamma measurements, without further soil sampling or in-situ measurements. This would only occur if a statement could be made such as "if gamma scan results over the entire property do not exceed background, and indoor Rn/Tn and indoor gamma indicates no contamination, then there is a high probability (exact probability to be determined in pilot study) that Ra-226 and Ra-228 soil concentrations are less than 5 pCi/g (total) at this property." If a high probability (i.e., greater than 95 percent confidence) cannot be placed on such a correlation, then additional in-situ measurements or soil sampling will occur before a property is considered a candidate for no removal.

If the outdoor gamma survey results are elevated above the discovery criteria and due to thorium tailings material (again as defined by the discovery criteria and using correlations established during the pilot study), the property will be a candidate for removal regardless of the results of the other measurements. Elevated indoor measurements may indicate that removal with depth may be needed, but the extent of the removal with depth will be established during removal actions.

Many of the property results will not likely be as straightforward as indicated above. Possibilities are (1) the results will conflict (elevated radon/thoron decay products and background outdoor gamma scans), (2) the results of one or more of the measurements will be inconclusive (a range will exist for each measurement where uncertainty exists over whether the result indicates contamination by tailings), (3) the property will be affected by shine from the Rare Earths Facility and the gamma scan results cannot be correlated with soil activity levels, or (4) the area of elevated activity is sufficiently small in area that the gamma scan does not adequately represent exposure rates. A property may also show elevated Rn/Tn decay product concentrations resulting from natural conditions (i.e., not related to thorium tailings).

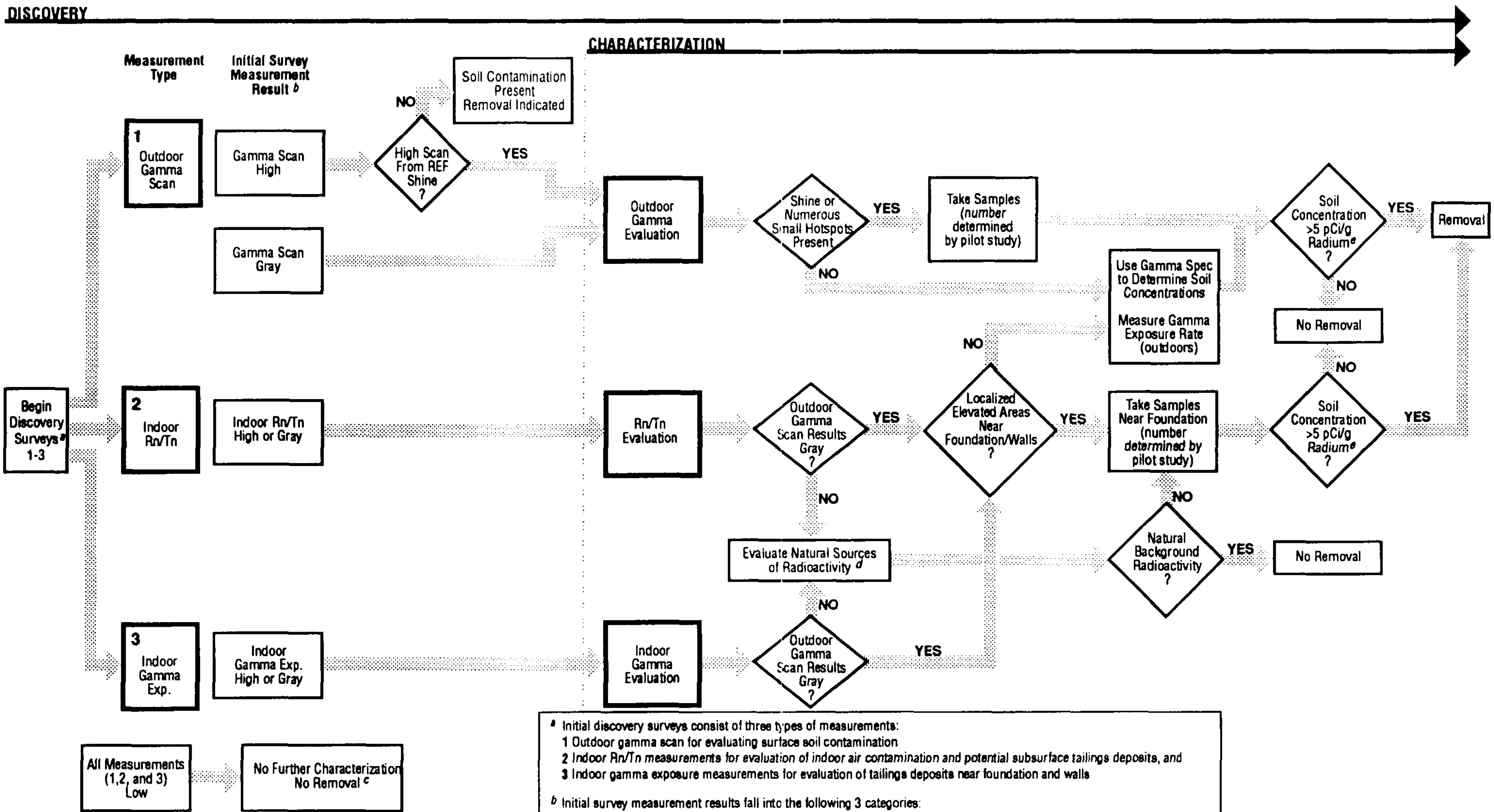
If these uncertainties exist, a characterization investigation will be conducted on these properties. The type of investigation will vary with the cause of the uncertainty. Figure 1-5 highlights the activities that could occur in order to make a decision about whether the discovery criteria have been exceeded and soil should be removed. In the areas where the gamma scan does not distinguish between contaminated or uncontaminated material at the discovery criteria level, in-situ gamma spectroscopy and exposure rates will be used or samples will be taken for analysis.

Where subsurface contamination is indicated as a result of obviously elevated indoor measurements (as defined during the air monitoring study) yet no evidence of surface contamination exists, subsurface soil samples will be taken next to the foundation to determine the cause of elevated indoor measurements. However, if the indoor monitoring results are inconclusive, further evaluation of the data and soil characteristics will occur before intrusive sampling is conducted.

A removal decision will be made after further characterization. Only evidence of soil contamination related to thorium tailings material exceeding the discovery criteria will result in a removal decision. If after further sampling or evaluation soil contamination is not evidenced to exceed the discovery criteria, no removal will be conducted. Elevated results will not necessitate removal if they are due to natural conditions or other radioactive materials that are not tied to the site.

Another purpose of the discovery phase of the investigation is to collect information to support the final RI/FS. A combination of surface soil sampling and radionuclide analysis, indoor and outdoor gamma exposure rates, and indoor Rn/Tn decay product measurements collected during the discovery phase will be used to support the final residual risk assessment at properties that do not require soil removals. The data will be used to delineate any remaining elevated levels of radionuclides. Additionally, during the pilot study, lead, chromium, and barium analyses will be done on the radiologically contaminated soil and background samples as discussed in the pilot study task to determine if these metals are contaminants of concern for the final residual risk assessment. Tables 1-1 and 1-2 summarized the final RI/FS uncertainties that will be addressed by data collection during the discovery phase of the project. The data planned for collection to support the removal action was also determined sufficient to support the final RI/FS.

Surveys and analyses collected on the clean backfill material used on properties that underwent removal activities along with verification surveys and analyses on the excavated areas will be used to support the final RI/FS.



a Initial discovery surveys consist of three types of measurements:
1 Outdoor gamma scan for evaluating surface soil contamination
2 Indoor Rn/Tn measurements for evaluation of indoor air contamination and potential subsurface tailings deposits, and
3 Indoor gamma exposure measurements for evaluation of tailings deposits near foundation and walls

b Initial survey measurement results fall into the following 3 categories:
HIGH Measurement clearly indicates contamination
GRAY Measurement result greater than background, but not clear evidence of contamination
LOW Measurement result equal to or less than background level- shows no evidence of contamination
A statistical evaluation of the pilot study results and Phase I indoor Rn/Tn and gamma measurement results will determine the "trigger" values for high, gray, and low for each measurement technique

c No further characterization/no removal may occur based on outdoor gamma scan, indoor Rn/Tn, and indoor gamma surveys only if a strong correlation is developed in the pilot study. This correlation must demonstrate that low results for each of these measurement techniques correspond to a high probability of soil concentrations less than 5 pCi/g total radium. This correlation must also hold through repeated testing (QC measurements) during the discovery and characterization fieldwork. If the correlation cannot be demonstrated (or fails QC testing), the investigation will proceed with an outdoor gamma evaluation to include soil sampling and/or in-situ gamma spectroscopy.

d Evaluation of natural sources of radioactivity may include additional follow-up measurements, evaluation of soil and building construction materials, and/or a review of regional background parameters from literature.

e 5 pCi/g above background and attributable to thorium tailings

Figure 1-5
Discovery and Characterization Process
Residential Areas Site Work Plan

Project Data Quality Objectives

The objectives of data collection are as follows:

- To collect outdoor gamma scan rates, indoor Rn/Tn decay product results, indoor gamma dose rates, and soil radionuclide information by soil sampling and in-situ gamma spectroscopy to assess where to conduct removal actions

- To collect soil radionuclide data, indoor Rn/Tn decay product data, outdoor gamma dose rates, and soil lead data to support a baseline risk assessment on the postremoval site

- To collect soil radionuclide data and outdoor gamma scan and dose measurements to assess the approximate extent of contaminated material left after the removal to support the final RI/FS. Indoor Rn and Tn decay product data will be used to supplement the outdoor information collected for the RI/FS and residual risk assessment.

Section 2
Project Approach

The overall objectives of this Work Assignment (WA) are (1) to develop an EE/CA that justifies the selected removal alternative, (2) to discover the residential sites requiring removal action, and (3) to conduct an RI/FS using discovery and verification information to evaluate whether contamination that remains may affect human health and what remediation may be warranted. To accomplish these objectives, the Work Assignment has been divided into standard tasks and subtasks that have been established for CH2M HILL's ARCS V Superfund Project Control System (SPCS). The use of these standard tasks enables the Work Assignment Manager and the Site Manager to track the progress of the project. Task and subtasks for this project are listed below:

- Administration and Program Management (Standard Task – AM)
  - Subtask AM.AS – Administration and Program Management Services
- Assessment of Risks (Standard Task – AR)
  - Subtask AR.HP – Human Populations
  - Subtask AR.DE – Data Evaluation
  - Subtask AR.PH – Human Health Residual Risk Assessment
- Enforcement Support (Standard Task – ES)
  - Subtask ES.MS – Miscellaneous Support
  - Subtask ES.SS – Enforcement Support
- Field Investigation (Standard Task – FI)
  - Subtask FI.FA – Indoor Radon/Thoron Monitoring and Gamma Radiation Measurements
  - Subtask FI.FC – Close Support Laboratory
  - Subtask FI.FK – Fieldwork Support
  - Subtask FI.FM – Mapping and Surveying
  - Subtask FI.FS – Soil Sampling
  - Subtask FI.GS – Radiological Characterization Surveys
  - Subtask FI.MS – Miscellaneous Support
  - Subtask FI.PT – Pilot Study
- Feasibility Study Report (Standard Task – FS)
  - Subtask FS.10 – EE/CA
  - Subtask FS.AD – Alternative Development and Screening

- Subtask FS.AE—Alternative Evaluation
- Subtask FS.AT—Alternative Technology Screening
- Subtask FS.EC—Estimates of Cost
- Subtask FS.R6—FS Report

- Project Planning (Standard Task—PP)

  - Subtask PP.10—Mini Work Plan
  - Subtask PP.20—Mini QAPjP
  - Subtask PP.MG—External Meetings
  - Subtask PP.PC—Project Closeout
  - Subtask PP.PM—Project Management
  - Subtask PP.QC—Quality Control
  - Subtask PP.QS—SAP and HSP
  - Subtask PP.WP—Work Plan

- Remedial Investigation Report (Standard Task—RI)

  - Subtask RI.R2—Draft RI Report
  - Subtask RI.R3—Final RI Report

- Sample Analysis/Validation (Standard Task—SA)

  - Subtask SA.DE—Data Evaluation
  - Subtask SA.DM—Data Management
  - Subtask SA.DV—Data Validation

For each subtask, a description of the work to be performed plus the basis for estimating the schedule and cost of the subtask (e.g., assumptions, number of meetings) have been identified. Level-of-effort hour and cost estimates are discussed in Section 4.

Task AM—Administration and Program Management

Task AM is included to allow for program management activities related directly to the Kerr-McGee Residential Areas site Work Assignment. Charges to this task are limited to those of the Program Manager and Contracts Administrator for support of the Work Assignment.

Subtask AM.AS—Administration and Program Management Services

Task Description

The Program Manager is responsible for all work performed under the ARCS V contract. The major responsibilities of the program manager are as follows:

- Oversight of work performed by the Site Manager
- Guidance and oversight of the support staff and other resources
- Oversight of the technical, schedule, and cost performance of the Work Assignment
- Guidance on ARCS V contract policies and requirements

Basis of Estimate

- Throughout the duration of the Work Assignment the Program Manager or Contracts Administrator will provide 2 P4 hours per month of program management support.
- The Project is estimated to be 46 months in duration.

Task AR–Assessment of Risks

Subtask AR.HP–Human Populations

Task Description

The purpose of this task is to collect information to identify, enumerate, and characterize human populations potentially exposed to contaminants within the Residential Areas site. Such information may include, but is not limited to, population size and location within the study area with particular consideration to identifying potentially sensitive subpopulations such as children, pregnant women, infants, and the chronically ill. Such information may be obtained from census data, as well as land use plans, zoning maps, and regional planning authorities. Information obtained will be entered into the Geographical Information System (GIS) database for later analysis.

Also, information concerning population-specific activity patterns within the study area for various subgroups may be collected to the extent practicable through visual observations and opportunistic questioning. Such observations and questioning may occur during the Access Arrangement subtask. A questionnaire designed to collect relevant information will be prepared for use during the Access Arrangement negotiations with residents. While this information may not be collected for the entire population, a statistically valid cross-section of the population will be surveyed. Results of this information gathering will be used in the Baseline Risk Assessment to define population-specific exposure parameters.

The results of the Human Population survey will be documented in the RI report. Also, a discussion of the relevance of the information will be included in the Baseline Risk Assessment, in particular in the Exposure Assessment and Risk Characterization.

Assumptions for this subtask include the following:

- Time required for collection of survey information will be included under the Access Arrangement subtask.

- Input and output of data to the GIS will be included under the Data Management subtask.

- A technical memorandum (TM) will be prepared to detail the results of the Human Population survey.

- Use of the results will be included under the Baseline Risk Assessment subtask.

Basis of Estimate

- Obtaining and completing a review of the census and other literature in order to obtain necessary population data is estimated to require 40 P1 hours and 40 P3 hours.

- Preparation of information acquisition sheets will require input from risk assessment, community relations, and statistics specialists. An estimate of 40 P3 hours and 20 P2 hours will be used.

- Database query is estimated at 24 P3 hours.

- Evaluation of the data generated from the survey may require 40 P3 statistician hours and 60 P3 risk assessment specialist hours.

Subtask AR.DE—Data Evaluation

Task Description

The purpose of this task is to assess the usability of validated data results on the basis of data comparisons to non-site-related conditions. Results that meet the Data Quality Objective (DQO) requirements and are considered usable will be compared with site-background sample results. Results of the data evaluation will be documented in the RI Report. Data comparisons and evaluations will be made as follows:

- Evaluation of detection levels
- Evaluation of counting errors
- Evaluation of qualified data
- Evaluation of equilibrium data
- Comparison of laboratory and field blanks with sample results
- Comparison of duplicate results

Contaminants of concern will be identified thorough an evaluation of the following criteria:

- Site-background results (using boxplots)
- Frequency of detects
- Extent of contamination

The contaminants of concern that are identified will be used in the risk assessment and the FS.

Basis of Estimate

- The level-of-effort to evaluate the RI data depends on the sample results and on the quality assurance/quality control (QA/QC) results. Assuming that no unusual field results occur, an estimate of 200 P3 hours is required.

- Eighty P3 statistician hours will be required to statistically evaluate the data.

- Eighty P2 hours are estimated to query the database.

Subtask AR.PH—Human Health Residual Risk Assessment

Task Description

The purpose of the human health residual risk assessment for the Residential Areas site is to estimate the potential residual risk to human health resulting from exposure to contaminants after removal actions. The human health residual risk assessment will be conducted in accordance with EPA methods for estimating health risks for Superfund using existing guidance, *EPA Risk Assessment Guidance for Superfund (RAGS): Volume I—Human Health Evaluation Manual (Part A)*, December 1989. The exposure factors in this guidance have been superseded by the OSWER Directive 9285.6-03, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (EPA, March 1991). Other applicable EPA risk assessment guidance will also be referenced. In addition, site-specific exposure factors derived from the Population Survey will be used as appropriate. The residual risk assessment will include site characterization summary, exposure assessment, toxicity assessment, and risk characterization. Uncertainties in the data evaluation will be discussed in the assessment to place risk estimates in perspective. This will include a qualitative evaluation to identify the site-related variables and assumptions that contribute to the uncertainty in the residual risk assessment. Results will be incorporated into the RI Report.

The primary sources of toxicological data to be used in the analysis will be the most current citations in EPA's Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST). The toxicity assessment will include a comprehensive discussion of the toxicological characteristics of the major contaminants at the site and of the quantitative approach used to assess the potential effects of the carcinogenic and noncarcinogenic effects on human health.

The exposure assessment will include the use of standard default and site-specific exposure factors where appropriate in estimating exposure (intake) via the exposure scenarios identified for the site. Both average and reasonable maximum exposure (RME) intake parameters will be assessed to provide a range of estimated exposures.

The radiological risk assessment for the investigation will generally follow the methods outlined in *RAGS*, Chapter 10. Risks from exposure to radiation will be calculated using methods described in the National Emission Standards for Hazardous Air Pollutants (NESHAPs) background documentation (EPA/520/1-89-005), and the intake to risk (slope) factors contained in the most current version of HEAST for radionuclides. Total cancer incidence risk from inhalation or ingestion of radioactive materials will be determined directly using the HEAST factors. To the extent possible, measured exposure rates will be used to determine risks associated with external gamma exposure from contaminated soils. Total cancer incidence risk from external radiation exposure will be calculated by taking the deep dose equivalent determined by direct measurements and applying the dose to the cancer incidence conversion factor for low linear energy transfer radiation specified in the NESHAPs documentation (6.2×10^{-4} per rad). Fatal cancer risk will not be calculated in this assessment.

The radiological risk characterization will use the same exposure assumptions (intake rates, days of exposure, etc.) that are used for the chemical risk characterization. The exposure assessment will follow the EPA exposure assessment guidance document published in the Federal Register on May 29, 1992.

The human health residual risk assessment will include, in accordance with the conceptual site model (Figure 1-4), evaluation of the following exposure scenarios:

- Adult and child receptors under a current resident scenario are considered probable human receptors. Appropriate exposure parameters typical of outdoor recreational activities (e.g., children playing in yards) derived either from the Population Survey or from EPA guidance will be used in assessing potential exposures to contaminants of concern. Primary routes of exposure for these receptors include incidental ingestion of contaminated surface soils and direct external gamma exposure from residual radioactive contaminants in sediments and soils.

- Other potential routes of exposure that are considered as part of the conceptual site model include ingestion of potentially contaminated vegetables and inhalation of Rn/Tn decay products emanating from soils. Ingestion of contaminants in vegetables will be evaluated using the results of soil samples with bioaccumulation factors for vegetation. Inhalation of Rn/Tn decay products will be evaluated using results from indoor air samples. In addition, a screening evaluation of dermal exposures from beta emitters in soil will be conducted using upper bound exposure parameters. Results from this screening evaluation will be used to determine if further quantitative evaluation of dermal exposures is necessary.

Risks will be calculated on a location- or sample-specific basis using sample data from each measurement location to determine potential risk at that location. Sample-specific risk calculations will also allow presentation of risk contours for the site, and calculation of surface areas (ft^2) that fall above or below specified risk levels. In addition, use of the sample-specific risk method provides much more realistic risk results, while retaining the ability to determine average or 95 percent upper confidence limit (UCL) risk levels for the site. This will provide a range of risks to which the population may be subject, recognizing uncertainties that may exist. Data collected during discovery and characterization phases and postremoval actions will be used in evaluating risks.

Risks will be calculated as total residual risk remaining after removal. Background risks will also be calculated and subtracted from the total risk for comparison purposes.

Basis of Estimate

- Only the exposure scenarios and exposure routes discussed above will be included in the human health risk assessment.

- Appropriate standard exposure parameters will be used in addition to site-specific parameters derived from the Population Survey task.

- Contaminants of concern are assumed to include the uranium and thorium decay series radionuclides in the risk assessment.

- The site characterization is estimated to take 16 P1 hours, 40 P3 hours, and 20 P4 hours for the draft report.

- The toxicity assessment is estimated to take 60 P4 hours and 132 P3 hours for the draft report. Information from the toxicity assessment developed for the Kerr-McGee RKP and the STP will be used, where appropriate. However, more detailed toxicity information for radionuclides will be prepared to address concerns of exposure to different age groups. This assessment will include generation of appropriate bioaccumulation factors for the ingestion pathway using results of the population survey. Also, a risk factor for Tn decay products must be developed using literature sources.

- The exposure assessment is estimated to take 200 P3 hours and 40 P2 hours for the draft report. P2 hours are used to retrieve data from the database.

- The risk characterization is estimated to take 80 P2 hours, 200 P3 hours, and 104 P4 hours to complete the draft assessment. P2 hours are used to retrieve data from the database. In addition, 80 P2 hours are estimated for calculation reviews.

- Costs for revising the risk assessment after receipt of EPA comments are included in Subtask RI.R2.

Task ES—Enforcement Support

Subtask ES.MS—Miscellaneous Support

Task Description

The purpose of this task is to provide technical assistance to EPA during project implementation through the Record of Decision for the Residential Areas site. Such support may include technical assistance in development and maintenance of the Administrative Record for the site, review of site-related documents prepared by other federal or state agencies, evaluations of interim storage locations, development of community relations fact sheets and briefing materials, and attendance at project-related meetings involving various state agencies and government representatives. The actual scope of work is not currently defined and will be directed by EPA as the need for technical support is identified.

Basis of Estimate

- Allowance of 150 P4 hours and 150 P3 hours
- Allowance of two meetings, two attendees per meeting

Subtask ES.SS—Enforcement Support

Task Description

The purpose of this task is to provide technical support to EPA during the EE/CA and/or RI/FS associated with enforcement aspects of the project during removal actions or remedial design/remedial action (RD/RA). Activities may include review of potentially responsible party (PRP) documents, attendance at negotiation meetings, assistance in preparation of technical briefing and decision documents, technical assistance for responsiveness summaries, and assistance with management and QC. The actual scope of work is not currently defined and will be as directed by EPA as the need for additional support is identified.

Basis of Estimate

- Allowance of 150 P4 hours and 150 P3 hours
- Allowance of two meetings, two attendees per meeting

Task FI–Field Investigation

Subtask FI.FA–Indoor Radon/Thoron Monitoring and Gamma Radiation Measurements

The objectives of indoor Rn/Tn decay product monitoring and gamma radiation measurement include supporting discovery operations, supporting characterization of nature and extent of contamination, and supporting the baseline risk assessment and FS.

This task will include Rn/Tn decay product monitoring during discovery operations to provide data on near worst-case, closed home conditions. To the extent possible, samples will be placed in residences according to procedures specified in EPA 402-R-92-004, "Indoor Radon and Radon Decay Product Measurement Device Protocols." However, the general practice will be to place devices in the lowest accessible area (crawlspace or basement) to achieve conservative Rn/Tn decay product measurements that will maximize the chances of finding properties with tailings contaminants. Residences that show low Rn/Tn decay product concentrations under such conditions probably do not have deposits of tailings materials near walls or floors that could cause exposures. Residences that show high Rn/Tn decay product measurements under these conditions will be candidates for follow-up measurements and further characterization, and/or removals.

Further characterization decisions will be based on evaluation of the source of the elevated Rn/Tn decay product concentrations. Background Rn/Tn decay product measurements will be taken in residences uncontaminated with tailings material. Those measurements will be used to determine both the background levels of Rn and Tn decay products, and the relative concentration ratio of decay product concentrations. An evaluation will be performed of the difference of the absolute concentrations and the ratios of Rn/Tn progeny in homes in background areas to homes in contaminated areas. This evaluation may also include a simple geological assessment of soil types in background and contaminated areas. Based on this evaluation, design criteria will be developed to trigger additional investigation at residences that show elevated Rn/Tn decay product concentrations. Residences that show elevated Rn/Tn decay product results that are attributed to natural conditions will not be candidates for characterization or removal actions (unless contaminants are found in another portion of the property). These residences may be covered under existing state and EPA programs for Rn mitigation. Residences that show elevated Rn/Tn decay product concentrations determined to be related to thorium mill tailings will be candidates for further characterization and/or removal actions.

Because discrimination of Rn decay products vs Tn decay products is necessary to determine the cause of elevated measurements (tailings or natural materials), a monitor system that accurately measures both Rn and Tn decay products is critical. EPA Region V health physics personnel have performed an evaluation of commercially available Rn/Tn decay product monitors, and determined that at this time the R.A.D. M-1 Surveymeter radon progeny integrating sampling unit (RPISU) best meets the needs of the discovery protocol.

Rn/Tn decay product monitoring will be performed during the winter months under closed house conditions. Sampling will be conducted in two phases. Phase I sampling will cover approximately 100 samples during January through March 1994. Data from this round of sampling will be evaluated prior to initiating subsequent rounds. Subsequent sampling rounds will be detailed in the full project work plan. Phase II sampling will occur during the winter months of 1995 and 1996. It is anticipated that approximately 80 houses will be sampled during Phase I using the R.A.D. M-1 surveymeter. Sample locations will include properties shown within the boundaries of the EG&G aerial gamma survey and other locations determined to be contaminated from IDNS survey data.

Indoor gamma radiation measurements will be taken at the same time as the RPISU samplers are placed. Gamma radiation measurements will be collected for discovery purposes only, and will consist of scanning the floor and walls in the lowest portion of the house being surveyed (basement or crawlspace if possible). Detailed grid surveys of the entire floor and wall area will not be conducted. A single average value for count rate or exposure rate will be used to characterize each wall and floor area. Gamma radiation measurements will be taken using either NaI gamma scintillation detectors or portable exposure or dose rate instruments (Micro-R or Micro-Rem instruments). Results from indoor gamma measurements will be compared with indoor gamma measurements at background locations for use in determining whether discovery criteria are exceeded. Background indoor gamma count or exposure rates will be determined using the results from indoor gamma surveys at uncontaminated properties.

Basis of Estimate

Phase I Sampling

- Two CH2M HILL employees will be required to take the Radon Measurement Proficiency (RMP) exam for Phase I sampling. This will require 22 T2 hours.

- Preparation for sampling, including procurement of the Rn/Tn sampler vendor to supply Rn/Tn decay product monitors, and initial set up and testing of samplers will require 8 P2 hours and 4 P4 hours.

- Phase I Indoor Rn/Tn decay product sampling will be conducted using the R.A.D. M-1 Surveymeter RPISU. A total of 100 samples (including background and QC) will be taken in batches of 25 samples each. Samplers will be placed in residences for 7 to 10 days, starting in early January 1994 and ending no later than mid-March 1994.

  M-1 samplers will cost $30 per unit. It is assumed that 100 units will be used for sampling and that batches of 25 samplers will be available for each of the sampling periods described above.

Samplers will be placed and retrieved by personnel from the CH2M HILL Oak Ridge and Chicago offices. It is anticipated that sample placement and collection will require 42 T2 hours, 40 P1 hours, and 180 P2 hours.

- Travel and expenses will include four trips between Oak Ridge and Chicago and 12 days of meals and lodging.

- Gamma radiation survey instrumentation rental will be $440 per month during the Phase I sampling.

- Review of field data and sampling procedures and initial evaluation and oversight of R.A.D. activities will require 20 P4 hours.

- An audit of the R.A.D. facilities in Rexdale, Ontario, Canada, will be performed during the Phase I sampling. This audit will require 30 P4 hours and 10 T2 hours. Travel and expenses will include one trip between Oak Ridge and Toronto and meals and lodging for 2 days.

- At the end of the Phase I sample effort, a follow-up intercomparison test of approximately 25 M-1 samplers will be conducted using the thoron chamber in Elliot Lake, Canada. Preparation, testing, and evaluation of results will require 80 P1 hours and 4 P4 hours. It is assumed that this test will include travel from Oak Ridge to Elliot Lake and 5 days of meals and lodging.

  Cost to use the Elliot Lake test chamber is assumed to be $5,000.

- A TM will be developed after completion of Phase I sampling activities. This TM will include evaluation of data collected during sampling and an evaluation of the results of the intercomparison testing. The TM will require 50 P1 hours, 20 T2 hours, and 4 P4 hours.

Phase II Sampling

- Two additional CH2M HILL employees will be required to take the RMP exam during the course of the Phase II sampling. This will require 24 P2 hours.

- Sampling will be conducted using the R.A.D. M-1 Surveymeter RPISU. Samplers will be placed in residences for 7 to 10 days during the winter months of 1995 (November 1994 through February 1995) and 1996 (November 1995 through January 1996).

  Rn/Tn analysis will average $40 per sample for Phase II sampling for a total cost of $76,000. The cost is based on the assumption that timers will be added to the M-1 units during Phase II sampling. Gamma surveys of the lower areas of each house (basement or crawlspace if possible) will be conducted when the Rn/Tn samples are placed. Labor for gamma surveys and placement and retrieval of Rn/Tn samples will average 1.5 P2 hours per location for a total of 3,000 P2 hours. Rn/Tn sampling and gamma surveys will require 429 P2 hours per month during the 7 winter months of Phase II sampling.

- One intercomparison test of M-1 samplers will be conducted during the winter of 1995 (Phase II sampling) using the thoron chamber in Elliot Lake, Canada. This test will require 80 P1 hours and 8 P4 hours. Travel will include one trip between ORO and Elliot Lake, Canada, and meals and lodging for 5 days.

  Cost to use the Elliot Lake test chamber is assumed to be $5,000 per event.

- Field data review and oversight of Rn/Tn sampling and gamma measurements will require 16 P4 hours per month during the 7 months of Phase II measurements, for a total of 112 P4 hours.

- Gamma radiation survey instrumentation will have been purchased for the Project under the Gamma Survey Task (FI.GS) and will be used for the Phase II survey in the winter months.

- A calibrator (Gilian "Gilibrator") will be used to check Rn/Tn pump calibrations. Cost for this unit is $895.

- Estimated expenses include two trips per month between Oak Ridge and Chicago and 26 days of lodging per month for seven months for one P2 for Phase II sampling.

Subtask FI.FC – Close Support Laboratory

Task Description

Soil samples will be analyzed in the IDNS close support laboratory (CSL). CH2M HILL will provide additional staff support and equipment as needed. Staff support will consist of technicians and/or chemists trained in radiochemistry. Funds for laboratory gamma spectroscopy equipment and labor hours will be budgeted for but not used until requested.

The CSL task includes general health physics counting instrumentation to support field activities. This instrumentation will include alpha and beta-gamma scalers for counting air samples and smear samples for contamination control purposes, portable alpha and beta gamma detectors with ratemeters for personnel "frisking," and calibration sources for these instruments.

Basis of Estimate

- The IDNS laboratory is assumed to handle all of the Residential Area site samples with a turnaround time of 2 days.

- Additional technical staff and instrumentation support to the IDNS lab will be provided as needed by EPA. Staff support is assumed to require 400 P2 hours in 1994 and 400 P2 hours in 1995.

- Gamma spectroscopy instrumentation and equipment to augment the IDNS lab capacity will include one 3 in. × 3 in. NaI detector, one high purity germanium (HPGe) detector compatible with the IDNS lab analysis equipment, and two low background shields. Cost for these items is $42,830. These items will be purchased only if needed to meet schedule milestones.

- Cost for general health physics counting and contamination control survey instrumentation and sources is $8,307.

Subtask FI.FK—Fieldwork Support

Task Description

This subtask is to provide support in the form of a field activities task manager and support personnel to coordinate and schedule all field activities. The field coordinator will be responsible for keeping field activities properly staffed and for coordinating the rotation of schedules for project personnel. This subtask will also provide the office space, vehicles, and support equipment needed to implement field activities. It is assumed that this subtask will be active for 22 months.

Basis of Estimate

- Four thousand eight hundred and forty (4,840) P3 hours (220 hours per month) will be used for the coordination of the field effort.

- One thousand nine hundred thirty six (1,936) office support hours (88 hours per month) will be used throughout the duration of the field effort.

- Two EPA vans will be used during the field effort.

- One van and four cars will be rented on a monthly basis to support the field effort. It is estimated the van will rent for $475 per month and the cars will each rent for $418 per month.

- Office space will be rented in the same complex as IDNS's laboratory. It is estimated that office space with utilities will cost $1,400 per month.

- One computer (estimated at $3,000) will be purchased to support field personnel during the field effort.

- One fax machine and one copy machine will be purchased for the office at $450 and $4,500, respectively.

- Three mobile phones will be purchased to support field activities at a total cost of $600.

- Office furniture will be rented at $275 per month for 22 months.

- A telephone system will be purchased for $2,500.

- Office janitorial services are estimated at $300 per month for 20 months.

Subtask FI.FM – Mapping and Surveying

Task Description

The objectives of this subtask are to provide parcel identification of the properties located within the study area. Properties in which sampling, surveying, or removal activities are conducted will be identified by Township, Range, Section, Quarter Section, and tax number. Additionally, a tabulation of properties within the study area by the 1/4 Section will be developed.

Locations of data points collected and base map development will be included under the Data Management task utilizing global positioning from the gamma surveying task and the GIS. It is also assumed that all property tax numbers and location information will be provided by the IDNS GIS.

Basis of Estimate

- It is estimated that 2,000 properties will require legal descriptions.

- Two hundred P4 hours will be used for senior review and task management.

- Five hundred P3 hours and 2,000 T2 hours will be used to assemble property location descriptions and 1/4 section tabulations.

- One hundred office support hours will be used throughout this task.

Subtask FI.FS – Soil Sampling

Task Description

The objectives of the surface soil sampling task are as follows:

- To provide data to update and confirm the relationships established during the pilot study between surface soil concentrations and in-situ gamma spectroscopy results

- To provide data on soil activity levels in areas where the gamma spectroscopy system cannot be used for quantitative soil concentration determination. This will include the areas near the Rare Earths Facility where elevated gamma levels (shine) are expected to interfere with the gamma spectroscopy system.

- To provide additional soil characterization data, as needed, based on results from indoor Rn/Tn measurements, gamma scan surveys, or gamma spectroscopy measurements.

Soil samples will be taken to confirm gamma spectroscopy results on a frequency of 15 percent (approximately one set of three composite samples per day assuming six to seven gamma spectroscopy measurements per day). Each gamma spectroscopy QA/QC sample will consist of five soil samples randomly distributed within a circle with a radius of 10 m centered on the in-situ gamma spectrometer. Samples will be collected at each of the five locations at depth intervals of zero to 3 in. (zero to 7.5 cm), zero to 6 in. (zero to 15 cm), and 6 to 12 in. (15 to 30 cm). Surface vegetation (leaves and roots) will not be included in the analysis of the shallow [zero to 3 in. (zero to 7.5 cm) and zero to 6 in. (zero to 15 cm)] samples. The five fractions at each interval will be composited into one sample for each depth interval. Three depth intervals are used for gamma spectroscopy QC samples because accurate contaminant depth distribution data are critical to obtaining quantitative results with the in-situ gamma spectroscopy system.

Samples collected for the purpose of determining soil activity levels at locations where the gamma spectroscopy system cannot be used will consist of surface samples at depth intervals of zero to 3 in. (zero to 7.5 cm), zero to 6 in. (zero to 15 cm), and 6 to 12 in. (15 to 30 cm). The shallow soil sample [zero to 3 in. (zero to 7.5 cm)] will provide an indication of potential windblown activity for risk assessment purposes at locations near the Rare Earths Facility. The other depth intervals will provide information for those properties contaminated by mechanisms other than windblown dust. Sample locations around the Rare Earths Facility site will be determined on the basis of results of the gamma scan surveys using the decision logic established during the pilot study. It is expected that six samples will be collected at each of approximately 400 properties adjacent to the Rare Earths Facility. These samples will consist of two shallow (zero to 3 in.) samples, two zero to 6 in. samples, and two 6 to 12 in. samples. Duplicate samples for the gamma spectroscopy interference sampling will be taken at a frequency of 10 percent.

Soil samples will be taken to further characterize properties that show results indicating potential contamination from other survey methods (gamma scan surveys, gamma spectroscopy measurements, indoor Rn/Tn decay product measurements, and/or indoor gamma measurements). This will include evaluation of localized areas of contamination or "hot spots." Characterization samples will be collected from the intervals of zero to 6 in. (zero to 15 cm), 6 to 12 in. (15 to 30 cm), and those greater than 1 ft (30 cm). A pool of 1,500 soil samples will be allocated for additional characterization measurements at properties that show an indication of potential contamination. The samples in this pool will be used as needed for characterization. The logic for allocation of characterization samples will be based on the results of the pilot study, and will include an evaluation of the survey data available for the property. Duplicate samples for characterization sampling will be taken at a frequency of 10 percent.

Table 2-1 shows a summary of expected soil samples for QA/QC, gamma spectroscopy interference, and characterization purposes.

Soil samples will be taken using two methods. Surface [zero to 3 in. (zero to 7.5 cm) and zero to 6 in. (zero to 15 cm)] samples will be collected using a golf course hole or cup "plugger." Samples collected from 6 to 12 in. (15 to 30 cm) or greater will be taken using a hand auger. Soil samples will be analyzed in the IDNS lab for gamma emitting radionuclides using gamma spectroscopy. Results will be reported for Ra-226 equivalent and Ra-228 equivalent, in pCi/g.

Basis of Estimate

- It is assumed that three [zero to 3 in. (zero to 7.5 cm), zero to 6 in. (zero to 15 cm), and 6 to 12 in. (15 to 30 cm) intervals] composite samples will be collected each day for in-situ gamma spectroscopy QA/QC.

- It is assumed that in-situ gamma spectroscopy cannot be used for quantitative analyses at approximately 400 properties near the Rare Earths Facility. For estimating purposes, it is assumed that six samples per property will be collected plus 10 percent duplicates for a total of 2,640 ($6 \times 400 \times 1.1$) samples in the areas adjacent to the Rare Earths Facility. Of the six total samples per property, two locations will be sampled for only the shallow surface interval of zero to 3 in. Two other sample locations will be selected and each sampled for the zero to 6 in. and 6 to 12 in. intervals.

- A pool of 1,500 samples (based on 150 properties with five sample locations and two sample depths) is established for characterization sampling. Duplicates will be collected at a frequency of 10 percent to give a total of 1,650 characterization samples.

Table 2-1
Summary of Expected Soil Samples

Sample Type/ Purpose	Sample Interval	Average Total Samples per day[a]	Total Samples	Comment
Gamma spectroscopy QC	0 to 3 in. (0 to 7.5 cm) 0 to 6 in. (0 to 15 cm) 6 to 12 in. (15 to 30 cm)	3	1,188	Sample for each interval is a composite taken from 5 random locations over a 10 m radius circle.
Gamma spectroscopy interferences	0 to 3 in. (0 to 7.5 cm) 0 to 6 in. (0 to 15 cm) 6 to 12 in. (15 to 30 cm)	36 (during 3 month period)	2,400 + 240 QC = 2,640	Assumes that samples taken at approximately 400 locations. Two samples per location from 0 to 3 in. (0 to 7.5 cm) interval. Two samples per location covering 0 to 6 in. (0 to 15 cm) and 6 to 12 in. (15 to 30 cm) interval. Total of 6 samples per property.
Characterization	0 to 6 in. (0 to 15 cm) 6 to 12 in. (15 to 30 cm) >1 ft (>30 cm)	4 (uniform—over 2 year period)	1,500 + 150 QC = 1,650	Samples taken from a pool of 1,500 samples

[a]For gamma spectroscopy QC and characterization samples, load is assumed to be relatively uniform. Sample rate for gamma spectroscopy interferences is assumed to be concentrated over a 3-month period while surveying around the factory site.

Note: Soil samples from pilot study (including background samples) not included in this task.

- Purchase of sample containers for radiological sample analyses is allocated at $16,500.

- Purchase of coolers for sample shipment is allocated at $2,500.

- Soil samples for the pilot study (including background samples) are not included as part of this task.

- The gamma spectroscopy specialist will collect soil samples for QA/QC purposes so that no additional labor will be required for these samples.

- Soil sampling at areas with gamma spectroscopy interferences and for characterization purposes is estimated to take 1/2 full time equivalent (FTE) (110 P2 hours per month) for a total of 1,870 P2 hours. The sample technician is assumed to be from the Chicago area so that no airfare, meals, or lodging are required. It is assumed that soil sampling for characterization or gamma spectroscopy interferences will be conducted during the months of April through November 1993, and March through November 1994, for a total of 17 months.

- Rental of additional field equipment [radiation survey (frisking) instrumentation] for soil sampling is allocated at $300 per month. This is equipment that may be needed in addition to equipment purchased for the gamma sampling task (FI.GS).

Subtask FI.MS – Miscellaneous Support

Task Description

The purpose of this subtask is to assist EPA in obtaining access agreements from property owners whose properties are part of the Kerr-McGee study area and that will be affected by field activities. CH2M HILL will develop a standard "request for access" letter (in English and Spanish) that will be attached to an official EPA Access agreement. This letter will be mailed to the appropriate property owners and then will be followed up by site visits from project personnel to answer any questions that owners may have. Because of the size and nature of the study area (potentially thousands of property owners), property records may be reviewed to determine ownership of properties included in the study area.

Additional activities in this task may include technical support to EPA for negotiations of access agreements for construction of roads or other activities related to the RI/FS.

Basis of Estimate

- Eighty P2 and P1 hours each will be used for initial access for indoor air sampling activities.

- One hundred sixty P2 and P1 hours each will be used for initial access for the pilot study and discovery activities.

- Eight P2 and P1 hours each per week will be used for continued access during the discovery and characterization activities, which are estimated to last for a total of 64 weeks.

- Eighty P3 hours are budgeted for assisting EPA in technical support with access negotiations and/or neighborhood block meetings to provide project understanding and status. Two round trips from Oak Ridge are also assumed for this support.

Subtask FI.PT – Pilot Study

Introduction and Objectives

A major objective of the West Chicago Residential Areas site is the development and application of consistent decision tools to be applied in real time during the process of site discovery. Development of effective decision tools will depend upon several factors including the ability to calibrate field and laboratory instrumentation to predict radionuclide concentrations in soils from gamma activity and/or spectral quantification with a prespecified level of confidence. Additional factors are background levels of gamma activity and radionuclide concentrations, the spatial distribution of contaminated materials throughout the project site, and the specific regulatory-defined project-specific action levels. A pilot study has been identified as a critical first step because the decision tools and activity or concentration cut points that can be used to effectively differentiate soils above and below project-specific action levels are pivotal to successful implementation of this program.

The proposed pilot study has been designed to address six primary objectives as follows:

- Establishment of background in terms of gamma exposure or count rates, radionuclide concentrations and, potentially, relative proportions of total radioactivity as well as levels of a subset of metals. Background levels will be quantified in residential areas that have, to the extent possible, been identified as not impacted by distribution of Kerr-McGee tailings.

- Quantification of the relationships among field measurements reported from gamma scans (counts of gamma activity), in-situ gamma spectra (including radionuclide-specific identification and quantification), and laboratory instrumentation that quantifies radionuclide concentrations from invasive soil samples. As part of this objective, the effect that mixing and compositing of soil samples has on the equilibrium of the thorium decay series will be evaluated. The results of this evaluation will be used to determine decay correction factors for soil samples.

- Development of action level for field instrumentation that trigger additional characterization measurements for areas indicating potential contamination greater than background. In addition, development of the decision logic that utilizes these action levels and specifies which additional characterization measurements should be utilized depending on which action levels are triggered.

- Evaluation of contamination distribution with soil depth. Several calibration algorithms may be used to determine soil concentrations from field gamma spectra measurements. One assumes that activity sources are homogeneously distributed through soils to a depth of 1 ft. Another assumes that sources are localized to a shallow surface layer. Other algorithms assume linear or exponential relationships for changes in contaminant concentration with depth. Resulting concentration estimates differ substantially. A reasonable assumption is that the depth distribution of radionuclides over soil depth will differ over the residential site. Invasive soil samples, in conjunction with spectra results, will be used to identify areas where specific calibration algorithms are appropriate.

- Evaluation of the effective range of available field methods with regard to the effects of elevated radiation levels (shine) near the Kerr-McGee Rare Earths Facility.

- Evaluation of levels of metals (barium, chromium, and lead) that trigger concerns from a disposal or risk perspective, and the relationship of these metals to concentrations of the radionuclides of concern. Levels of barium, chromium and lead in soils collected at the Kerr-McGee Rare Earths Facility are elevated above levels quantified from background samples collected in the field investigations at other Kerr-McGee sites. Barium and lead in some samples have exceeded hazardous materials levels, indicating potential constraints to disposal options if metals are attributable to Kerr-McGee processing. Action levels specific to the Residential Areas site are limited to radiological levels. Data from the pilot study will be used to indicate (1) the extent to which disposal is constrained by metals concentrations in contaminated materials and (2) the potential health risk posed by concentrations of metals in residual materials that are less than EPA project-specific action levels, not requiring removal.

The pilot study will establish the decision tools that will be used throughout the discovery and characterization process. Ranges of surface gamma scan activity counts are expected to correlate predictably to specific radionuclide levels (or possibly, ratios of radionuclides) as quantified by in-situ gamma spectroscopy, which will also correlate to soil concentrations of both radionuclides and metals, as quantified by laboratory analyses. These relationships, calibrated from the pilot study data, will be applied during the discovery and characterization process of the gamma surveys over the entire Residential Areas site. An ongoing QA/QC component of discovery surveys over the entire

Residential Areas site will be conducted to corroborate the decision tools established during the pilot study. Deviations from the relationship of activity to radionuclide levels will signal the need to recalibrate or respecify decision tools developed with pilot data.

A detailed task description of the pilot study is presented in the following section, followed by a description of analytical and statistical methods that will be applied to pilot study data to accomplish the objectives listed above.

Task Description

The pilot study includes field surface gamma scan surveys, field radionuclide spectra collection identification and quantification, and laboratory identification and quantification of radionuclides and lead, chromium, and barium in soil samples to be conducted on both a portion of the Residential Areas site and area(s) that represent background conditions. Survey and all spectra and sample locations will be supplemented with Global Positioning System (GPS) for coordinate location to automate mapping of field instrument responses and laboratory results.

The surface area to be surveyed with the gamma scan represents 5-ft-wide (1.5 m) transects of approximately 5.2 miles (8.4 km) and 28.6 miles (46 km) in the background and Residential Areas site, respectively. These mileages represent between 0.6 to 0.9 percent (background) and 3.4 to 5.0 percent of the estimated total surface area of the Residential Areas site. Assuming an average width of 4,200 ft (1,280 m) results in approximately 35 transects crossing the Residential Areas site from east to west.

In-situ gamma spectroscopy measurements will be conducted at 30 randomly assigned locations [representing an integrated area of an approximate 33 ft [10 m radius circle to a penetration depth of approximately 1 ft (0.3 m)] in the background area. The statistical rationale for the sample size of 30 relies upon a nonparametric method (Conover, 1980). A sample size of 30 gives 95 percent confidence that the maximum will be equal to or greater than the 90th percentile of the population sampled.

Soils from five randomly located samples [at three depths: from zero to 3 in. (zero to 7.5 cm), zero to 6 in. (zero to 15 cm), and 6 to 12 in. (15 to 30 cm)] will be composited into one sample per depth from each of the 30 spectra areas and quantified for radionuclide-specific identification and activity. The same radionuclide identification/quantification, coupled with invasive soil sample collections, will be performed at approximately 90 Residential Areas site locations, resulting in 90 sets of spectra results and 270 soil samples (from three depths).

The 90 Residential Areas site locations and 30 background locations will also be sampled for lead, chromium, and barium in soils. The metals analysis will only be performed on samples taken from the zero to 6 in (zero to 15 cm) interval.

Results from 10 percent duplication (of transects scanned, spectra set and quantified, and samples analyzed for radionuclides and metals) will be used to estimate sampling variability. Table 2-2 illustrates samples to be collected during the pilot study.

The locations of spectra and soil sample collection in the Residential Areas site will be identified on the basis of gamma scan results. The distribution of the complete set of gamma scan results from the Residential Areas site will be used to bracket three categories of soils: (1) less than or equal to background; (2) greater than background but not clearly contaminated; and (3) contaminated. While the proportion of detailed sampling allocated to each of the categories will be prioritized to focus on the Category 2 locations, even distribution of a sample size of 90 across the three categories (as identified through the gamma scan) results in statistical confidence comparable to that allocated to the background area. The specific allocations assigned to background, contaminated, and intermediate locations will be determined during the pilot study and will be based upon both the relative proportion of gamma scan survey results (among the three categories) and the variability in the scan/spectra relationships observed in Category 2 results.

Statistical Methods

Statistical analysis of field results from the pilot study will involve a variety of analytical methods including exploratory analyses, tolerance intervals, regression, and classification and regression trees (CART). The following briefly describes each of these methods, supplemented with hypothetical examples, and discusses how the methods may be applied in development of decision tools that can be used during the discovery and characterization portions of the study. The extent to which application of these methods will achieve the program goals is not currently known and will depend upon the strength of the relationships between radionuclide concentrations in soils as measured with available field instrumentation. Statistical analyses will be performed using Systat/Sygraph and S+ software. Systat/Sygraph was developed by Leland Wilkinson, et al. (Evanston, Illinois). S+ was originally developed by AT&T and is currently distributed by Statistical Sciences, Inc. (Seattle, Washington).

Exploratory Analyses. Exploratory analyses consist of graphical methods including probability plots, boxplots, scatter plot matrices, and identity plots. Probability plots are used to identify data distributions. Boxplots graphically compare distributions from different data subsets (e.g., background vs contaminated soils). Scatterplots of spectral and invasive sample results will be used in evaluating the effect of shine. The plots will be used to target where the correlation of spectra and laboratory results diverge. Samples associated with discrepant results (i.e., higher spectral results due to interference from facility shine) will be mapped to define the boundary beyond which spectra quantifications will not be considered an option to verify contamination.

Scatterplot matrices graphically display relationships among multiple variables and will be used to identify variables that can provide the best predicted values. The best predictors are anticipated to be transformations or aggregations of raw measurements. For example,

Table 2-2
Pilot Study Sample Summary

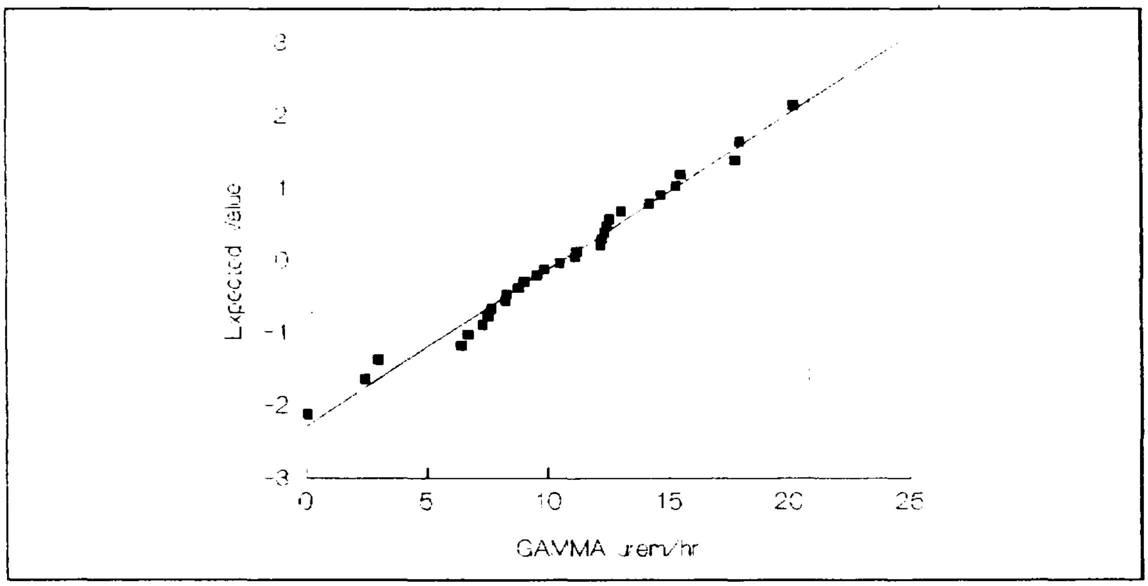
		Soil Samples		
	Spectra	**Radionuclide Analyses**	**Lead Analyses**	**Comment**
Background	30	90	30	3 composite samples from 3 depth intervals at each location. Lead on only zero- to 6-in. interval.
Residential Area	90	270	90	3 composite samples from 3 depth intervals at each location. Lead on only zero- to 6-in. interval.
Quality Control	12	36	12	10 percent duplicates.
Total	132	396	132	

a summed concentration of gamma emitters may correlate with gamma count data better than the concentration of any single emitter. Similarly, it would not be surprising if the ratio of K-40 to Ra-226 will provide a better indicator of background than either the gamma scan or K-40 separately.

Identification of best-predictor variables will be based upon exploratory analyses and corroborated with comparison of goodness of fit statistics and residual behavior after fitting appropriate regression and/or CART models.

Tolerance Intervals. Data from the background locations will be used to estimate upper bounds of background gamma scans, radionuclide concentrations, and (potentially) ratios of naturally occurring radionuclides (K-40) to nuclides that occur naturally but are augmented with by-products of thorium processing (Th-232, Ra-226). Tolerance intervals rely upon sample statistics to estimate levels below which a specified proportion of the sampled population are expected (with a specified level of confidence). Tolerance intervals are calculated with parametric or nonparametric methods, as appropriate, based upon the distribution of the variable.

The following plot displays a hypothetical distribution of observed levels of gamma activity from background areas. The linearity of the probability plot (expected value against observed measurement) indicates a normal distribution. The sample estimates of average (X-bar) and standard deviation (SD) were used to calculate an upper tolerance limit of expected values, indicated with the broken line.



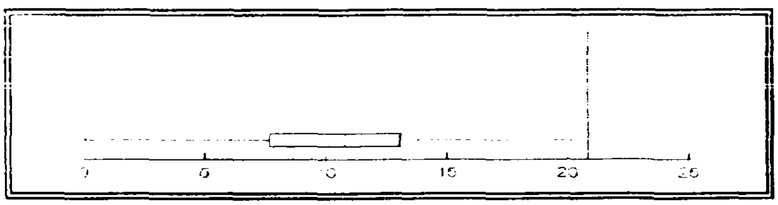
Hypothetical Distribution of Background Gamma Activity
Broken Line **= Upper Tolerance Interval**

The upper limit is calculated:

$$UL=\overline{X}+t_{1-\alpha,n}*[SD]$$

where $t_{1-\alpha,n}$ is the tabled value of the Student's T distribution for a specified confidence $(1-\alpha)$ and sample size (n).

The double-boxed inset is a boxplot that is a non-parametric display of the same observations, ranked in increasing activity. The plot delineates (1) the upper and lower 25 percent of the observations with the edges on the right and left sides of the box; (2) the median, the line approximately midway in the box; and (3) the range of observations, corresponding to the scale opposite the ends of the whiskers. Alternative upper tolerance limits may be calculated using order statistics if data are not normally distributed or cannot be transformed into a normal distribution (e.g., a log transformation).



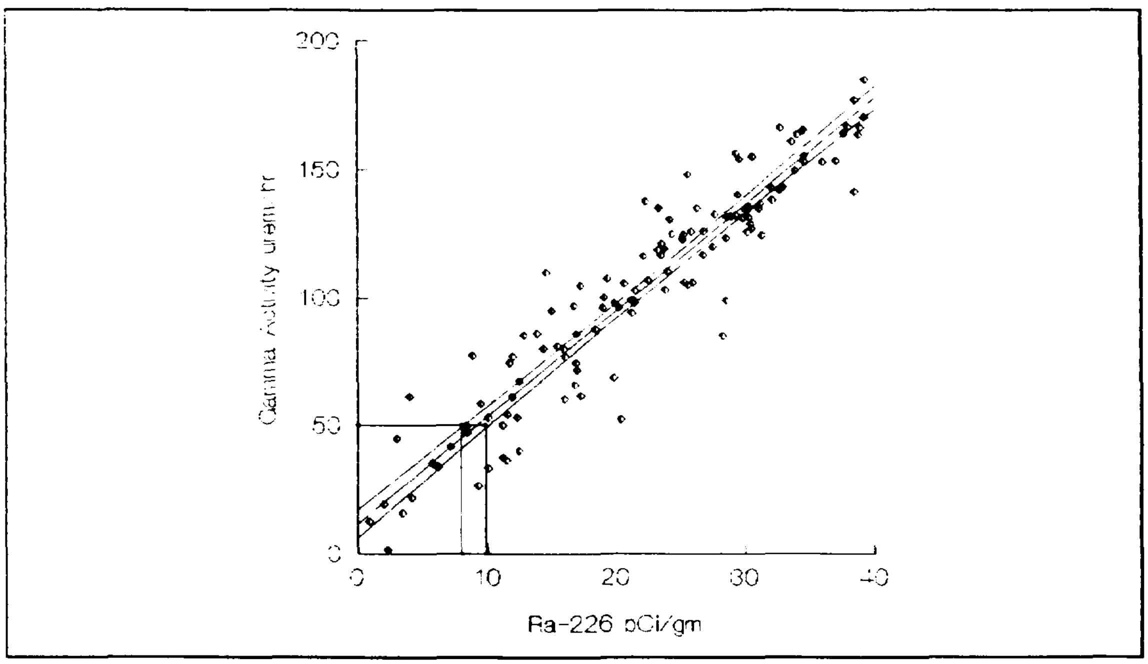
Box & Whiskers Plot Inset

Upper tolerance intervals derived from background data may be used to provide lower bounds on field and laboratory measurements that are indicative of contamination. Exceedance of tolerance intervals will target locations that require either further sampling and analysis or remediation. The interest in background is (1) to establish a lower bound of gamma scan that triggers no further sampling except for routine QA/QC documentation that detailed radionuclide identification/quantification corresponds with previous results and (2) to identify areas that exceed background but that may lie below the current action level.

Regression. The more difficult boundary to define will be the interval that includes the overlap of soils with radionuclide levels less than the action level and soils that clearly exceed the action level. Extremely contaminated soils pose comparatively reduced uncertainty. To quantify the region around the action level, calibration methods will be applied to pilot data to derive the range of gamma scans associated with specific soil concentrations (e.g., the 5 pCi/g above background project-specific action level). Regression methods that quantify the relationship between a known parameter and a dependent parameter will be used to establish intervals in the gamma scan that correspond to specific nuclide levels. Certain assumptions of classical regression techniques may not be rigorously met in this study. Specifically, regression methods assume that the independent variable is errorless. As long as the relative variability of the dependent and independent variables approach this condition, the methodology holds. Conventional regression methods may be used to estimate a calibration curve (regression line) between the predictor variable, which is measured with greater accuracy (e.g., gamma spectra or laboratory quantification), and a less accurately measured variable (e.g., gamma scan). A variety of curves may be used, as appropriate, based upon the behavior of the data being modeled including linear, log linear, quadratic, and cubic.

The confidence interval about the modeled regression line can then be used to predict the interval (upper and lower limit) of the dependent variable associated with a particular value in the predictor (the 5 pCi/g action limit). Inverse regression methods, which represent a simple rearrangement of terms from standard regression models, may be used to estimate the interval of predictor values associated with a specific value in the dependent variable. Successive intervals (called fiducial limits) on the independent variable could then be used to estimate probabilities associated with specific gamma counts.

The following plot displays a hypothetical linear regression between Ra-226 concentration (independent variable) and gamma dose rate (dependent variable). The 95 percent confidence interval about the line can be used to derive fiducial limits on the range of Ra-226 concentrations corresponding to a measurement in gamma dose rate, the dependent variable. Inverse regression techniques would be used to calculate the probability of exceeding an unmeasured level of Ra-226 concentrations in associated soils.



Ra-226 and Gamma Dose Rate: Linear Regression

Fiducial Limits define the range of expected Ra-226 values at 50 μrem/hour gamma dose rate.

CART. CART methods are an extension of classical regression techniques (Breiman et al., 1984). They are used to define a sequence of cut points in several variables ultimately result in classification of results into discrete groupings. The method is the collection of a sequence of rules in multiple predictors, which are displayed in a tree similar to a decision diagram. Advantages to CART are the relative simplicity of the model, the ease in calculating the probability of misclassification, and the easily interpreted graphical results. Assuming that expected relationships among the field measurements hold and CART results in acceptable levels of misclassification using the pilot study data, the resulting model would be a simple sequence of decision tools that would classify soils as background, at the project-specific action level and exceeding the action level.

Basis of Estimate

- One hundred twelve P3 statistician hours will be required to prepare for the pilot study. This will include an evaluation of the IDNS mapping; delineation of study transections; completing diagnostic calculations for calibration of linear, lognormal, and quadratic inverse regressions; coding tolerance internal calculation options; coding some normal tests; and developing linkages of data from various instrumentation into the statistics package software.

- Forty P4 health physicist hours will be required as part of the preparation for the pilot test. This will include working with the statistician on development of the statistical tests and protocols listed above and assisting with the startup of the gamma spectroscopy system.

- Two hundred sixty P3 statistician hours, 260 P4 health physicist hours, 340 P3 hours, and 880 T2 hours will be required to conduct the pilot study. This will include evaluation of data generated as part of the study, development of decision criteria for the residential properties surveys, and development of a technical justification document for use of in-situ gamma spectroscopy.

- Travel will include four (two each) trips between ORO and CHI for one P4 and two P3s; four trips (two each) for two T2s; and two trips between SEA and ORO, and two trips between SEA and CHI for one P3.

Subtask FI.GS—Radiological Characterization Surveys

Task Description

Purpose. Radiological characterization surveys will be performed at each property within the Residential Areas site. The objectives of the radiological surveys are as follows:

- To determine if surface soils contain thorium tailings contamination in amounts greater than the EPA's "discovery" criteria

- To determine the radioactive contaminants, contaminant concentrations, and contaminant distributions as needed to direct removal operations at those properties with contamination levels greater than the discovery criteria

- To provide radiological characterization data for use in a risk assessment, RI, and FS at those properties with contamination levels less than the discovery criteria

The radiological characterization surveys will consist of surface gamma scanning (walkover) measurements, in-situ gamma spectroscopy measurements, and exposure rate measurements. Surface gamma scan surveys will be conducted at each property considered as part of the Residential Areas site. Gamma spectroscopy and exposure rate measurements will be used as needed to provide additional data for characterization and risk assessment purposes. The decision to use these additional survey techniques (as well as soil sampling—discussed under task FI.FS) at a particular property will be made after review of the gamma scan results for that property. A preliminary description of the decision logic for discovery and characterization surveys is shown in Figure 1-5. This logic will be updated on the basis of results of the pilot study.

Gamma Scanning Surveys. Gamma scanning surveys will provide data on the location, surface distribution, and relative amount (based on count rate) of surface soil contamination. Radiation survey instrumentation coupled to a GPS will be used for the gamma scanning survey at each property.

Gamma scanning measurements will be taken using 2 in. $\times$ 2 in. NaI detectors coupled to Ludlum model 2221 ratemeter/scalers. These measurements will be recorded as count rate at approximately 6 in. above the ground surface. The surveyor will walk along transects (spaced approximately 5-ft apart) across the property while slowly swinging the NaI detector over the ground surface. Count rate data will be recorded every 2 sec and coupled with a position coordinate from the GPS using a Trimble TDC-1 data logger. The count rate result and coordinate for each measurement will be recorded in a data file for that property. Gamma scans will be conducted so that approximately 100 percent of the accessible surface of each property is surveyed.

The NAVSTAR GPS will be used to establish horizontal positions for the continuous gamma scan data obtained from the radiation walkover survey. In order to relate the gamma scan data to the existing IDNS GIS base mapping, the horizontal positions must be related to the same horizontal coordinate system used for the existing site base mapping. Following the collection of the gamma scan data, a GIS base map will be plotted displaying the results of the radiation walkover survey.

An accuracy goal for the horizontal positional data has been set at the plus or minus 1-m range. This accuracy goal was selected for the following reasons:

- The goal is sufficiently accurate to reflect the locations of the gamma scan data relative to the base mapping available.
- The goal can be efficiently achieved using GPS technology when appropriate procedures and equipment are employed—Code Phase differentially corrected using carrier-phase GPS receivers.

GPS was selected as the positions system for the following reasons:

- GPS technology can be used to achieve the accuracy goal with little effect on the overall production.
- Line of site is not required because it is in conventional and transponder surveys; thus, little time will be spent establishing control or setting up equipment on a daily basis.
- The GPS system allows tying field measurements from digital devices directly to the datalogger used to record GPS position observations.
- GPS will allow repeated measurements at the same location without additional surveying of a grid.

Positions on the ground, both horizontal and vertical, are determined by using GPS receivers to collect signals from a minimum of four satellites to calculate the position of the receivers. From these signals, users can determine their position anywhere worldwide. As a result of signal delays and errors deliberately added by the Department of Defense, real-time uncorrected positions are accurate to 100 m. By using suitable equipment and by following appropriate procedures, subcentimeter accuracies can be obtained.

Horizontal accuracy can be improved using a method called differential GPS. By recording GPS signals at a known location simultaneously with data being recorded by a roving unit, differential corrects can be applied to improve the accuracy of the rover position. Gamma Scanning Measurements will be located using GPS carrier phase-receivers collecting code-phase GPS signals. Differential corrections will be applied to the code-phase positions to achieve the stated accuracy goals of plus or minus 1 m. Survey grade control stations will be established onsite and will serve as a known point for the base station observations. The base station observations will be the basis for code-phase differential corrections.

For properties where the GPS system cannot be used (because the GPS signals are lost due to interferences caused by buildings, trees, or other structures), positions for gamma scan surveys will be obtained using grid or radiological survey procedures. A total station or baseline grid, oriented to two GPS stations, will be used to develop geodetic positions for the gamma scan sample points. The total station in the radiological survey mode can record any position requested by the gamma scan team. The gamma scan team will record the gamma reading or transmit it to the total station operator by voice or radio. The gamma reading can be keyed into the total station data recorder as an attribute to the geodetic position or logged with the grid position on a field data entry form where a grid is used. X and Y coordinates, and gamma readings for each point observed in the field will be computed and stored in an ASCI file for entry in the GIS data base. The total station may be used to develop grid lines in areas where grids are used.

Gamma Spectroscopy. In-situ gamma spectroscopy measurements will be taken at designated properties that show gamma scan survey results at background levels or slightly elevated above background levels, but not high enough to be classed as contaminated without further characterization. The slightly elevated properties are considered in a "grey zone" where gamma scan survey results are elevated, but could result from normal variations in natural background levels or low levels of thorium tailings contamination. The range of gamma scan count rates corresponding to background radiation levels will be established in the pilot study. Calibration correlations and decision logic to determine which properties should be surveyed with the in-situ gamma spectroscopy system will be determined in the pilot study. It is anticipated that in-situ gamma spectroscopy will be used primarily for characterization surveys, but may also be used during discovery surveys in place of soil sampling.

A gamma spectrometer can accurately identify and quantify gamma emitting radionuclides in environmental media. Gamma spectroscopy will be used to determine approximate soil concentrations and/or to determine the proportion of gamma radiation from background sources vs Kerr-McGee source material. These data will be used with the gamma scanning results to determine if a property is considered contaminated, and thus a candidate for removal, based on the discovery criteria. It will also be used to help determine if soil samples should be taken, and if so, how many samples should be taken at that property.

Quantitative estimates of surface soil concentrations will be determined from gamma spectroscopy results using methods developed at the Department of Energy's Environmental Measurements Laboratory (EML). The EML has developed a method for calibrating a portable gamma spectroscopy system positioned at 1 m above the ground surface, so that soil concentrations can be determined for individual radionuclides. The EML method calibration factors are dependent on soil contaminant distribution, detector size and efficiency, and detector orientation (looking up or looking down). In addition, this method is dependent on having a relatively uniform areal distribution of contaminants across the detector field of view (approximately 314 m^2). Thus, it will only be used for quantitative soil concentration measurements in areas shown by gamma scan surveys to have a relatively uniform distribution of contaminants over the surface surveyed. This method will not be used to provide quantitative soil concentration estimates at "hot spots" or to average out hot spot concentrations over a larger surface area.

Of the calibration factors needed for this method, only the soil contaminant distribution is site specific. Soil contaminant distributions over the range of conditions expected at this site will be determined during the pilot study. These distributions are expected to range from surface deposition only (windblown areas) to more uniform contamination to a depth of approximately 1 ft (30 cm) (based on conditions generally found during the cleanups conducted by Kerr-McGee in the mid-1980s).

The in-situ gamma spectroscopy system will be calibrated and tested during the pilot study. Soil samples will be collected at each spectra measurement location to develop and confirm the system calibration. The calibration will be tested continuously during the discovery survey process through collection and laboratory analysis of surface soil samples from spectra measurement locations at a frequency of 15 percent. In addition, duplicate and known spectral analyses will be performed at a frequency of 10 percent each.

Exposure or Dose Rate Surveys. Exposure or dose rate measurements will be taken at a height of 1 m at selected properties using a tissue equivalent dose rate instrument pressurized ion chamber (PIC), or gamma scintillation detector calibrated to exposure rate for the mixture of gamma energies of concern at this site. These locations will include at a minimum each gamma spectroscopy survey location. In addition, 1 m gamma exposure measurements will be taken at 10 percent of the properties determined to be uncontaminated based on gamma scan results.

Exposure rate data may be used with in-situ gamma spectroscopy results as part of the characterization process to determine the proportion of gamma radiation related to background sources vs thorium tailings material. This information would be useful at locations showing elevated exposure rates caused by naturally occurring radionuclides (such as K-40 in fertilizer on a garden). For properties determined to be uncontaminated, the exposure rate data will also be used for the risk assessment.

Basis of Estimate

Radiation Survey/GPS System Development

- Establishing geodetic site control, establishing a GPS base station, and setting the field data collection system are estimated to take 68 P3 hours and 60 T2 hours. Meals and lodging for 14 days are included.

- Conducting a system live field test on the base station, field collection system, and postprocessing is estimated to take 124 P3 hours and

20 T2 hours. Estimated expenses include one round-trip airfare from Washington Dulles to Chicago, and 17 days' meals and lodging.

- Conducting a system train for the base station, field collection system, and post processing is estimated to take 64 P3 hours and 24 T2 hours. Estimated expenses include 10 days' meals and lodging. Estimated costs for GPS consulting services are included as part of the radiological survey operations section below.

- Cost to upgrade the IDNS GPS system to work as a radiation survey system is $17,540.

- Configuration and testing of the GPS/radiological survey system is estimated to take 80 P4 health physicist hours, 120 P3 hours, and 880 T2 hours. Estimated expenses include six round-trip airfares from Oak Ridge to Chicago, and 112 days' meals and lodging.

Radiological Survey Operations

- It is assumed that approximately 2,000 properties must be surveyed over a 2-year period (two construction seasons running from March through November). This estimate of number of surveys is based on an approximate count of the properties shown under the gamma contours from the EG&G aerial survey, adding additional surveys for repeat measurements, and assuming a 20 percent safety factor.

  It is assumed that approximately six surveys will be completed per day over each 9-month period. This schedule will be adjusted as required once fieldwork begins so that all 2,000 properties are covered in 2 years.

  Surface gamma scan surveys will be conducted by two teams of two technicians each. One technician on each team will operate the radiation survey instrumentation and one technician will operate the GPS instrumentation. It is assumed that each team will be able to completely survey three properties per 10-hr field day (including instrument setup and checkout time, in-field data checking, postsurvey instrument checkout, and daily documentation requirements).

  The gamma scan survey subtask is estimated to take 440 hours per month of HP technician (T2) time, and 440 hours per month of GPS technician (T2) time. Total HP technician/GPS technician time over the 2-year period (18 months) will be 15,840 T2 hours (including the 880 hr shown above for configuration testing).

  Estimated expenses include six trips per month between Oak Ridge and Chicago for three T2s, and 78 days per month meals and lodging for three T2s (26 days per month per technician). Total travel is estimated at 108 trips between Oak Ridge and Chicago and 1,404 days' of meals and lodging for the survey teams.

Purchase and maintenance of the GPS/radiological survey system have been allocated at $82,000.

- The engineers' estimate for GPS consulting services (including GPS system development, testing, and training tasks) is $260,277.

  This task also includes oversight by a senior surveyor, GPS consulting site oversight, and remote GPS support. The senior surveyor oversight activity is estimated to take 468 P3 hours and 18 days' of meals and lodging.

- In-situ gamma spectroscopy surveys will be conducted at properties that show elevated gamma scan results using the decision protocols established in the pilot study. It is expected that gamma spectroscopy will be used primarily at those properties in the "grey zone" (elevated gamma scan results, but not clearly contaminated). It is estimated that six gamma spectroscopy measurements can be made each day.

  The engineers' estimate for gamma spectroscopy services to support the field activities is $341,105.

  Purchase and maintenance of the gamma spectroscopy system have been allocated at $53,000.

  Costs for a liquid nitrogen service for the gamma spectrometer will be $143 per month for a total of $2,717 (for 19 months).

  Exposure rate measurements will be taken as needed during the gamma spectroscopy measurement period. Therefore, no additional labor hours are required for this activity. The total cost for purchase and annual maintenance and recalibration of instrumentation for measuring exposure rates is $1,668.

  Cost for purchase of a computer for the gamma spectroscopy system is $3,600.

Data Review and Oversight of Radiological Operations

- A health physicist will provide oversight for the radiological survey operations and periodically review data generated by the field teams. This individual will assist field teams in decisionmaking related to selection of locations for more detailed characterization (gamma spectroscopy measurements and sampling).

- Forty P4 hours per month will be used for review and oversight of radiological field operations. Estimated expenses include one trip per month between Oak Ridge and Chicago (18 trips total), and lodging and meals for 2 days per month during field operations (36 days total) for one P4.

Task FS—Feasibility Study Report

This task includes activities to conduct the EE/CA and to complete the final FS at the Residential Areas site. Project management and QC for these tasks are budgeted under Task PP—Project Planning.

Subtask FS.10—EE/CA

Task Description

Two alternatives, including the no-action alternative and a removal and offsite disposal, will be developed under this task. The alternative will be developed in detail (including an estimate of the volume required for removal and disposal). The individual and comparative analysis of effectiveness and implementability will also be conducted. This analysis will include assessing short-term risks to workers and the community during implementation, as well as residual risks from material left behind.

An ALARA plan will be included in the EE/CA because the discovery criteria selected is 5 pCi/g total radium above background but cleanup is to proceed to ALARA. This ALARA plan will describe to what level soil is removed under various site conditions. It will illustrate how to make field decisions about when to stop excavating by considering volume, cost, access, and risk reduction benefit.

A +50/-30 percent cost estimate will also be developed. Capital costs, operation and maintenance costs, and present worth costs will be developed, as appropriate, for one alternative.

The task includes preparation of the internal review draft and all technical and report modifications resulting from the internal review. As part of the submission to the EPA and the state, the document will include a recommended alternative based on the evaluation in the EE/CA. The agency review draft document will be based on existing information. EPA and state comments will be addressed in a public review draft. It is assumed that neither the new data nor EPA or state comments will add or delete any alternatives. A preliminary draft of the outline of the EE/CA is presented in Figure 2-1.

After completion of the pilot study, the EE/CA cost estimate and volume estimates will be reevaluated. A memorandum presenting this reevaluation will be submitted to EPA. This will enable EPA to amend the EE/CA to refine the cost and volume estimates if needed.

Figure 2-1
Engineering Evaluation/Cost Analysis Outline

1 Introduction
- General Purpose of an EE/CA
- Site Eligibility for EPA Response
- Location
- Regulatory Strategy for the Residential Areas Site

2 Residential Areas Site Characterization
- Background
- Site Physical Setting
  - Physiography
  - Geology
  - Hydrogeology
  - Surface Water Hydrology
  - Surrounding Land Use
  - Climatology
  - Natural Background Radiation
- Past Investigations and Responses
- Site Conditions that Justify a Removal Action
  - Nature of Contamination
  - Conceptual Site Model
  - Preliminary Risk Assessment

3 Removal Action Objectives
- Response Authority
- Removal Scope and Purpose
- Removal Schedule
- Regulatory Requirements

4 Identification of Removal Action Alternatives
- Response Action Identification and Screening
  - Radon and Thoron Reduction
  - Institutional Controls
  - Containment
  - Excavation and Restoration
  - Treatment
  - Interim Storage
  - Final Disposal

Figure 2-1

Engineering Evaluation/Cost Analysis Outline

Identification of Preliminary Alternatives
Conceptual-Level Description of Source Removal Alternative
- Excavation and Restoration
- Packaging and Transportation
- Final Disposal
- Waste Volumes

5 Evaluation of Alternatives
Effectiveness
- Protection of Public Health
- Protection of the Environment
- Compliance with ARARs
- Reduction of Toxicity, Mobility, or Volume Through Treatment

Implementation
- Technical Feasibility
- Administrative Feasibility
- Availability of Services and Materials
- State Acceptance
- Community Acceptance

Cost
Comparative Analysis for Removal Action Alternatives
Recommended Removal Action Alternative

6 Applications of ALARA

Basis of Estimate

- Forty P2 hours to estimate volumes for remediation based on existing data is included in the cost estimate. Detailing the alternatives sufficiently to conduct the evaluation will require another 40 P2 hours, 40 P3 hours, and 80 P4 hours.

- Conducting the short-term and long-term risk assessments and the evaluation of the alternative will use 60 P3, 40 P1, and 80 P4 hours.

- The ALARA Plan is estimated to use 100 P4 and 100 P3 hours.

- A total of 12 P4 hours and 40 P2 hours will be used to conduct the initial cost estimate.

- Another 10 P2 hours is estimated for revising the cost estimate for the final document.

- One agency review draft will be produced, of which 17 copies will be provided to EPA (including 2 for the State), while 5 internal copies will also be produced. The report is estimated to be 100 pages in length. One public review draft will be produced with the same distribution as the agency review draft.

- Five MacIntosh figures will be included in the report; production of these figures is estimated at 2 T2 hours per figure. Another 5 hours is allocated to revise figures for the final report.

- An estimate of 40 P3 hours is given to produce the agency review draft report, and an additional 80 P3 hours to revise the EE/CA (based on EPA comments) and to produce the public review draft. In addition, 24 P3 engineering hours are included to respond to agency comments in a memorandum. It is assumed that no new alternatives are added to the document.

- An estimated 80 P4 hours, 62 P2 hours, and 120 T2 hours will be used to reevaluate volume and cost estimates based upon pilot study results.

Subtask FS.AD—Alternatives Development and Screening

Task Description

The primary objective of this task is to develop an appropriate range of remedial alternatives that will be analyzed more fully in the AE subtask. These alternatives are developed from technologies remaining after screening (Subtask AT). Because of the removal action that will be complete at this time, limited options are likely to remain. It is not envisioned that sufficient alternatives will be developed to require an alternative screening step. Upon completion of the development of alternatives, an alternative array TM will be produced for regulatory concurrence with the alternatives and for obtaining state ARARs for incorporation into the FS document.

Basis of Estimate

- It is assumed that no more than three alternatives (including the no-action alternative) will be developed. It is estimated that approximately 60 P3 hours and 60 P2 hours will be used to combine representative response actions and cleanup levels into alternatives and develop them in sufficient detail that a TM for concurrence and state ARARs identification can be produced.

- Approximately 40 P3 hours will be used to write the TM. It is anticipated that the TM will be reviewed internally, and with another 24 P3 hours, produced for EPA. Comments from EPA and the state will be incorporated into the FS report.

Subtask FS.AE – Alternatives Evaluation

Task Description

The alternatives evaluation subtask is the analysis of the sitewide alternatives that were developed in Subtask AD. The evaluation consists of three steps: (1) defining the alternatives sufficiently to support a +50/-30 percent cost estimate, (2) analyzing the alternatives individually with regard to seven of EPA's nine evaluation criteria (state and community acceptance will not be evaluated in the FS), and (3) comparing the alternatives with regard to the same criteria. The purpose of this task is to develop information that will help decisionmakers select the appropriate alternatives for this site.

Basis of Estimate

- Disciplines such as civil engineers and health physicists will be used to support the definition and evaluation of alternatives, along with regulatory specialists and risk assessors. Approximately 60 P1, 80 P3, and 80 P4 hours will be used to define the alternatives; 100 P3 and 60 P4 hours will be used to conduct the individual analysis; and 80 P3 hours will be used to conduct the comparative analysis.

- Technical modification to the definition and evaluation as a result of EPA review is considered part of the report tasks.

Subtask FS.AT – Alternative Technology Screening

Task Description

Remedial action objectives will be developed under this subtask. Federal and state contaminant-specific ARARs and disposal waste acceptance criteria will be identified and incorporated into the objectives along with risk-based levels, if appropriate. Approximate volumes and areas of contamination will be identified on the basis of various potential cleanup objectives. Potential technologies and response options that are suitable for assembling into remedial alternatives during Subtask AD will be identified and screened.

Basis of Estimate

- Development of the remedial response objectives and evaluations of the federal and state contaminant- and location-specific ARARs will involve 24 P3 hours and will be based on work completed for the EE/CA.

- Soil removal, treatment, and disposal technologies will be screened on the basis of technical implementability. Only soil remediation technologies will be considered. As part of the technical implementability screening, the approximate volume of contaminated soil will be identified using information and maps from the database system. An estimated 60 P3 hours will be used to determine volumes of contaminated soil. Approximately 40 P2 hours will be used to complete the technology screening.

- Technical revisions that are needed as a result of EPA review are budgeted under the report subtask.

Subtask FS.EC – Estimates of Cost

Task Description

This subtask is used to monitor the scope of work associated with costing the final alternatives. A +50/-30 percent cost estimate will be developed using information from the definition of alternatives developed in Subtask AE. As part of this task, a schedule for implementing the alternatives will be developed to support the cost estimate. Capital costs, operation and maintenance costs, and present worth costs will be developed as appropriate for up to three alternatives.

Basis of Estimate

- A P4 cost estimator will travel once to Oak Ridge from Gainesville, Florida, and stay a total of 2 working days. A total of 24 P4 hours and 80 P2 hours will be used to conduct the initial cost estimate, with another 32 P3 hours used to coordinate and document the effort.

- A P4 scheduler will use 30 hours to estimate the implementation schedule for the three alternatives.

Subtask FS.R6—FS Report

Task Description

This task is used to track expenditures for preparing the agency review and public review drafts of the FS report. The task includes preparation of the internal review draft (using information from Subtasks AT, AD, AE, and EC) and all technical and report modifications resulting from the internal review. It also includes modifying the document after EPA and state review. It is assumed that EPA or state comments will not significantly change, add, or delete any alternatives.

Basis of Estimate

- One agency review draft will be produced, of which 17 copies will be provided to EPA (including 2 for the State), while 5 internal copies will also be produced. The report is estimated to be 300 pages in length.

- One public review draft will be produced with the same distribution as the agency review draft.

- Approximately 10 database figures are estimated to be included in the report. Costs for producing these maps are budgeted under Task SA.DM. An additional 20 MacIntosh figures will be included in the report. An estimate of 2 T2 hours per MacIntosh figure is used in the cost estimate for the original drawings, and half that estimate to revise the figures.

- An estimate of 100 P3 hours and 120 P2 hours is given to produce the agency review draft report, and an additional 40 P3 hours and 60 P2 hours to produce the public review draft. In addition, 40 P3 engineering hours are included to respond to agency comments in a memorandum. It is assumed that no new alternatives are added to the document.

Task PP—Project Planning

Subtask PP.10—Mini Work Plan

Task Description

The mini work plan task included developing the sampling rationale, activity description, budget, and schedule for implementing the Phase I indoor air sampling and gamma measurements task. The budget for this Rn/Tn monitoring task is incorporated into the

FI.FA task. The work plan development costs are tracked separately from the planning of the rest of the project tasks. The development of this work plan and the associated QAPjP allows this task to begin earlier than the other activities—during the winter when houses are closed thereby providing a more conservative estimate of the presence of Rn/Tn. Both a draft and a final version of the work plan are produced under this task.

Basis of Estimate

- The draft mini work plan used 44 T2 hours, 12 P3 hours, and 34 P4 hours to develop the sampling rationale, the task description, the schedule, and the budget.

- The final mini work plan is estimated to use 29 P4 hours, 6 P3 hours, and 25 T2 hours to address comments received from EPA.

Subtask PP.20—Mini QAPjP

Task Description

A QAPjP and associated Field Sampling Plan (FSP) were produced under this subtask. The QAPjP stipulated the DQOs, data management procedures, and QC procedures for the indoor Rn/Tn task. The FSP indicated the proposed sampling locations, procedures, and equipment for testing and analyzing for Rn and Tn. These plans were developed just for the Rn/Tn monitoring to allow this task to begin early during the winter. Because Rn/Tn monitoring will also be conducted beyond the effort scoped in the mini work plan, much of the information in the mini QAPjP will also be submitted in the project QAPjP.

Basis of Estimate

- The draft mini QAPjP used 4 T2 hours, 4 P3 hours, and 34 P4 hours including the hours used to develop the FSP.

- The final QAPjP and FSP are estimated to be produced for 16 P4 hours, 5 P3 hours, 18 P1 hours, and 11 T2 hours.

Subtask PP.MG—External Meetings

Task Description

This subtask includes meetings with the EPA, the State of Illinois, and/or other agencies or parties as agreed to by EPA. The following specific meetings are planned:

- Kickoff meeting and technical scoping meeting, including field visit (2 persons, 5 days; 1 person, 2 days)

- Pre-QAPjP technical scoping meetings (2 persons, 1 day)
- Work plan review meeting (2 persons, 1 day)
- Two work plan technical review meetings (2 persons, 1 day)
- EE/CA review meeting (2 persons, 1 day)
- Two work plan revision meetings (2 persons, 1 day)
- Risk Assessment scoping meeting (2 persons, 1 day)
- RI Report review meeting (2 persons, 1 day)
- Alternatives Development review meeting (2 persons, 1 day)
- FS review meeting (2 persons, 1 day)
- Miscellaneous meetings—18 each (1 person, 1 day). These meetings will be called by the Remedial Project Manager or will be to resolve coordination issues with the other participants in the project.

Basis of Estimate

- The kickoff meeting used 44 P3 hours and 60 P4 hours including preparation and a site visit.
- All of the review meetings are estimated to use 16 P3 and 16 P4 hours each. The 16 hours includes travel time, preparation time, and meeting time.
- The one-person meetings are estimated at 1 P3, 16 hours each including travel time, preparation time, and meeting time.
- Round-trip airfare from Oak Ridge to Chicago is estimated at $648.

Subtask PP.PC—Project Closeout

Task Description

This subtask includes activities to complete or close out the technical and financial aspects of the project following completion of the FS. The subtask includes the following activities:

- Organizing file records
- Indexing files to be microfilmed

- Closing out project subcontracts
- Completing the work assignment closeout request

Basis of Estimate

- It is assumed that 160 hours for the Site Manager (P3) and 240 office support hours will be used over a 45-day period to close out the project.

- It is assumed that the files can be microfilmed for $3,600.

Subtask PP.PM – Project Management

Task Description

This subtask includes project management activities throughout the project duration. These activities include the following:

- Managing contractor staff and resources

- Monitoring budget and schedule

- Preparing monthly progress reports (technical, financial, and schedule status)

- Routine communication with the EPA Work Assignment Manager, Project Officer, and Contracting Officer along with other team members such as IDNS. Specific progress meeting attendance will be included under Subtask PP.MG.

- Procuring and managing subcontractors

Basis of Estimate

- The Site Manager will spend 80 P3 hours per month for budget management (forecasting, review progress made, solving problems); schedule management; staffing; and coordination with the Work Assignment Manager and IDNS.

- The Assistant Site Manager will spend 20 P4 hours per month during the field activity phase (through December 1995). After this period, hours budgeted for the Site Manager will accommodate activities from both the Site Manager and Assistant Site Manager.

- Two hundred fifty P4 hours are budgeted for procurement activities at the beginning of the project. An additional 8 P4 hours per month are included for long-term procurement activities.

- The project is estimated to be 46 months in duration.

Subtask PP.QC – Quality Control

Task Description

A review team will examine each project deliverable prepared prior to submittal to EPA. The Review Team Leader will direct the review activities and will provide technical direction as needed. The review teams will consist of up to four professionals from appropriate disciplines with experience related to the problems at the site. Draft project deliverables include the Work Plan, the Sampling and Analysis Plan (SAP), the Health and Safety Plan (HSP), the EE/CA, the RI report, the Alternative Development Technical Memorandum, and the FS report. The other deliverables that will be reviewed include the mini work plan, the mini QAPjP, and the letter memorandum to EPA following the indoor air sampling activity.

Also included in the QC subtask is the review of field procedures through periodic field audits. These audits will evaluate how the QAPjP is being followed and will review the field team's image in light of the residential work area.

Basis of Estimate

- The Review Team Leader will provide 4 P4 hours per month of direction and technical support.

- Sixteen P4 hours will be used to direct and focus work plan development.

- Eight P4 hours were used to review the mini work plan and the mini QAPjP.

- The work plan will be reviewed using 24 P4 hours and 4 P3 hours, while 24 P4 hours will be used to review the SAP and HSP.

- An estimate of 18 P4 hours is provided to review the EE/CA. The personnel will specialize in geotechnical, nuclear, and chemical engineering.

- The letter memorandum completed after the initial air monitoring activity will be reviewed for 8 P4 hours.

- The RI report, including the baseline risk assessment, will be reviewed by 3 P4s using an estimated 12 hours each. These reviewers will have specialties in risk assessment, radiochemistry, and engineering.

- A P4 process engineer, P4 health physicist, and P4 geotechnical engineer will review the Alternative Development Technical Memorandum for 4 hours each and the FS report for 8 hours each for a total of 36 hours.

- Four field audits will be performed using 2 P4 hours for one week (80 P4 hours per audit). It is assumed that one of the P4s will be from Oak Ridge and the other will be from Milwaukee.

Subtask PP.QS–SAP and HSP

Task Description

This subtask provides for the preparation of specific project plans. These plans for the proposed field activities include the following:

- FSP. The FSP and QAPjP together make up the SAP. The FSP will indicate proposed sampling locations, procedures, and equipment for sampling and testing.

- QAPjP. The QAPjP will stipulate the data quality management objectives and procedures in accordance with the EPA Region V Model QAPjP.

- HSP. The HSP will describe procedures and protocols for personnel monitoring, protective equipment, training, and responsibilities in accordance with 29 CFR 1910.120.

- Waste Management Plan. The Waste Management Plan (WMP) will indicate proposed procedures for handling and disposing of investigation-derived mixed wastes, including Personal Protective Equipment (PPE), decontamination residuals, and laboratory residuals. The Kress Creek WMP will be used as the model.

The draft plans will be submitted for review by EPA and a final copy incorporating review comments will be submitted for approval. The final copy of the HSP will be provided to the agency for information only.

Basis of Estimate

- The HSP will use 16 P1 hours to prepare the draft and 2 P4 hours to revise and produce a final plan. The Kress Creek HSP will be the basis for the residential area HSP.

- The Waste Management Plan will use 8 P3 hours to prepare and 2 P3 hours to revise the plan. Again, the Kress Creek document will be the primary source of information.

- The FSP portion of the SAP will use 220 P4 hours, 184 P3 hours, 60 P2 hours, 117 P1 hours, and 280 T2 hours to prepare the first draft and revise after receipt of EPA comments.

- The QAPjP will use 71 P4 hours, 80 P3 hours, and 50 P1 hours to prepare the draft and final versions. The QAPjP will be developed using the existing Region V Model QAPjP.

- Support for preparation of these documents will be provided by other offices. Consequently, the costs include one round-trip from Gainesville, Florida, to Oak Ridge with 2 weeks of per diem expenses, and one round-trip from Seattle to Oak Ridge with 2 weeks of per diem expenses. Round-trip airfare is estimated at $612 for Gainesville to Oak Ridge and $1,540 from Seattle to Oak Ridge.

- A subcontractor cost of $6,500 is provided to allow the GPS subcontractor to provide procedures relevant to the QAPjP and FSP.

Subtask PP.WP – Work Plan

Task Description

This subtask includes the formulation of sampling rationale; DQOs; EE/CA, sampling, and RI/FS activity descriptions; and the preparation of the work plan, budgets, and schedules for implementing the proposed scope of work. The work plan summarizes existing information concerning site characteristics and the nature and extent of contamination. The work plan task includes development of the conceptual site model, a preliminary risk assessment, and preliminary remedial action objectives. A draft work plan will be prepared for agency review and a final copy incorporating review comments will be submitted for approval. Also included in this task are two annual work plan revisions.

Basis of Estimate

- The initial draft of the work plan used 280 P4 hours, 560 P3 hours, 84 P1 hours, and 40 T2 hours.

- The revision to the work plan based on EPA comments will use an estimated 60 P4 hours, 50 P3 hours, 51 P1 hours, and 8 T2 hours.

- Future work plan revisions are estimated to use 80 P3 hours.

Task RI – Remedial Investigation Report

Subtask RI.R2 – Draft RI Report

Task Description

This task will be used to interpret data and to write and produce an agency review draft of the RI report in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The report will include appropriate sections on site background investigation including both the "discovery" phase and the verification phase-activities, physical characteristics, nature and extent of contamination, fate and transport, and baseline risk assessment. The report conclusions will be developed around all data collected for the residential areas – both data collected during this project and data collected during other projects. However, for those areas that were remediated by the removal action, verification data will be used to assess the remaining conditions.

Basis of Estimate

- Seventeen copies will be submitted to EPA (two copies will be for the State). Another five copies will be made for internal use.

- The report is estimated to be 1,500 pages long (including the appendices and the residual risk assessment) and will be bound in 5 volumes. It will be based on the data evaluation conducted on the discovery and verification data in Task SA.DE.

- Figures will be produced from the database system as well as from the MacIntosh. It is estimated that 30 database figures and 20 MacIntosh figures will be produced at 2 T2 hours per MacIntosh figure. Production of the database figures is budgeted under SA.DM.

- An estimate of 100 P3 hours is included to request and evaluate data and maps from the database system. Data will be retrieved in the form of statistical reports and overlaid on maps, as appropriate, to evaluate and present the data.

- Describing the nature and extent of soil contamination using the results of soil analytical and radiological walkover data (both discovery data for non-removed sites and verification data for removed sites) will use an estimated 80 P4 radiochemist hours, 100 P3 hours, and 150 P2 hours. The number of hours assigned is a reflection of the low level (if any) of contamination that is expected to be present. Trends and correlations are more difficult to identify with very low levels of contamination.

- It is assumed that the levels of contamination found in soils remaining after the removal action will be so low that fate and transport of the soil contamination through the subsurface or through erosion will not be pertinent and will not be quantitatively addressed in the RI report. A brief discussion of air migration of particles and Rn from any remaining contamination will be provided.

- Evaluation and documentation of the indoor air monitoring data are estimated to use 60 P1 hours. However, it is assumed that no contamination is found and that the fate and transport of air contaminants are not needed.

- Writing the background section, the site investigation activities section, the conclusions, and the executive summary, along with coordinating the production of the report and the appendices, will take approximately 200 P3 and 80 P1 hours.

- This task includes developing the internal review draft and the agency review draft of the RI report.

Subtask RI.R3 – Final RI Report

Task Description

This subtask includes preparation of the final RI report following receipt of agency review comments on the draft RI report.

Basis of Estimate

- Seventeen copies of the report will be submitted to EPA (2 for the State). Another 10 copies will be for internal use. The document is assumed to be 1,000 pages long.

- It is assumed that comments received will not result in a redirection in approach. For instance, if it is concluded that no contamination is present at the site, comments received are not assumed to be significant enough to change the focus to identifying boundaries of contamination.

- Forty P3 hours are estimated for responding to comments in writing.

- Revision of the report is estimated to take 40 P4 hours, 120 P3 hours, and 40 P1 hours. Another 24 P4 hours, 80 P2 hours, and 16 P1 hours for risk assessment changes are included.

- Revisions to graphics are estimated at 20 T2 hours, half the estimate used for the draft RI report.

Task SA—Sample Analysis/Validation

Subtask SA.DE—Data Evaluation

Task Description

This data evaluation subtask will incorporate the evaluation of surface gamma surveys, gamma spectroscopy results, indoor air sampling results, and analytical results from soil samples collected during the discovery and characterization phases of the Residential Areas site fieldwork (Tasks FI.GS, FI.FA, and FI.FS). These data will be evaluated on a property by property basis against the EPA Action Criteria for removal actions to determine if properties are candidates for removal action or note. Evaluation packages will be prepared that will show the results of the surveys and supporting gamma spectroscopy and analytical results. The evaluation packages will include recommendations regarding actions to be taken on the basis of EPA's Action Criteria. These packages will be sent to EPA on a weekly basis for making removal decisions, and then passed on to the remediation contractor.

Additionally, the data evaluation subtask will incorporate the evaluation of verification data packages received from IDNS. These packages will be reviewed to determine if removal actions have met the remedial objectives established in the discovery phase of the project. The results of this evaluation will be summarized in the RI report.

Basis of Estimate

- Four thousand thirty two P3 hours (168 hours per month for 24 months) will be used to conduct data evaluation and prepare the evaluation packages for submittal to EPA and to review verification data packages from IDNS for compliance with remedial objectives.

- One thousand one hundred fifty two P4 hours (48 hours per month for 24 months) and 240 P3 hours (10 hours per month for 24 months) will be used for review of the evaluation and verification packages.

- Four hundred eighty office hours (20 hours per month) will be used for development of the evaluation packages.

- GIS operator and hardware/software charges are included under the data management task (SA.DM).

Subtask SA.DM – Data Management

Task Description

The purpose of this task is to provide data management, database/GIS design, and procedures associated with the Kerr-McGee Residential Areas site RI/FS. Most of the data to be collected is geographic in nature, i.e., referenced to known locations on the ground and appropriate for presentation in the form of maps. Therefore, the data management system will be based on a GIS, which will store geographic or spatial data and will be used to perform map analyses and presentation. The GIS will be accompanied by a tabular relational database management system (DBMS) that will store tabular data, such as field sampling results. The GIS and DBMS will reside on one hardware platform, will be linked together through the design data structure, and will operate in tandem.

The data management task has the following objectives:

- Establish a controlled, functional, and efficiently operated data management system and accompanying procedures that are necessary to validate, manage, analyze, document, and transfer the environmental database that is collected and generated in support of the RI/FS.

- Maintain a usable and accurate database throughout the life of the RI/FS.

- Process the specific data download requests by project staff, which will allow them to generate the required analyses and reports of the RI.

- Prepare and maintain documentation and perform training to support database users.

- Transfer the database to EPA and other parties, as appropriate.

- Archive the database and related documentation upon project closeout.

Database User Requirements

The principal users of the Kerr-McGee RI data will be CH2M HILL RI/FS project staff. These users will be a part of one or more of the three major technical support teams: RI, FS, and Human Health Risk Assessment.

The Data Management task will support the following RI activities at the user level:

- Data evaluation
- Exposure assessment
- Toxicity assessment
- Risk characterization

- Report preparation
- Residual risk assessment
- External meetings

In order to perform the above activities, users will require access to the project environmental database for such functions as data query, summarization, statistical analyses, and report generation.

Data Management System Components

The data management system described in this task is comprised of the following components:

- Computer hardware and software
- Data model and data organization
- Data management procedures

Computer Hardware and Software

A computer hardware/software configuration has been designed for this project to effectively handle the projected technical and analytical requirements of the RI/FS tasks. The system will be located in the CH2M Hill Oak Ridge, Tennessee, office.

The computer hardware/software system that will be used to manage the Kerr-McGee database is modeled after a "client-server" architecture. The key features of this architecture are as follows:

- A centralized database is stored in one location (the "server") under limited and controlled access.

- Several users ("clients") are permitted read-only access to the central database in order to download data to their individual computers.

- Any analyses or presentation of the tabular data involves "distributed processing," that is, using the processors and software available on the users' local computers.

The central hardware platform (the server) is a SUN SPARC Station 10 UNIX-based workstation with the following components:

Main processor:	SUN SPARC 10, Model 40 32 mb memory 2 gb disk storage 19 in. color monitor internal diskette drive

Peripherals:	SUN 8 mm tape drive SUN CD ROM drive Calcomp digitizing tablet Calcomp pen plotter

Additional IBM-compatible personal computers (the clients') may be connected to the server workstation through a local-area network. These personal computers can then be used by project staff to perform local processing on portions of the database for specific uses.

Software

The data management system will be based on a GIS to handle geographic features and their attributes. The GIS software selected for this project is Arc/Info from Environmental Systems Research Institute (ESRI). Arc/Info is the only commercially available GIS with the power, analytical capabilities, display capabilities, storage capacity, and data exchange features necessary for practical management, analysis, and display of geographic data on this project. Arc/Info is also the software completely compatible with the systems currently operated by all members of the technical team (IDNS, EPA, GIS Solutions, Inc., and CH2M HILL), thereby allowing easy data exchange and the distribution of GIS tasks among the team. ESRI fully supports Arc/Info through upgrades, online phone consultation, documentation and training programs, and onsite technical assistance.

The DBMS software selected for this project is Oracle. Oracle is accessed directly by Arc/Info through Arc's Database Integrator module. Oracle is widely considered to be a state-of-the-art DBMS, and provides greater power, functionality, and ease of use than Info, which is provided with Arc/Info.

Data Model and Data Organization

The project environmental database will reside on the hardware/software system described above. The database structure can be visualized in two parts—the GIS and DBMS—as shown in Figure 2-2.

The GIS database will be stored in Arc/Info as a set of "coverages," or thematic file sets, each containing the coordinates and spatial relationships necessary to represent a given map theme or layer. Typical map coverages in Arc/Info include parcel boundaries, field sampling locations, and streets. The GIS database will follow the Arc/Info standard data model. Geographic features will be represented as points, lines, and polygons registered to the Illinois State Plane coordinate system. Logical groups of features (such as water sample locations) will be grouped into thematic coverages, which will be linked to attribute tables that contain selected attributes for the geographic features. The Arc/Info data model is described in detail in the document *ARC/INFO Data Model, Concepts, & Key Terms*.

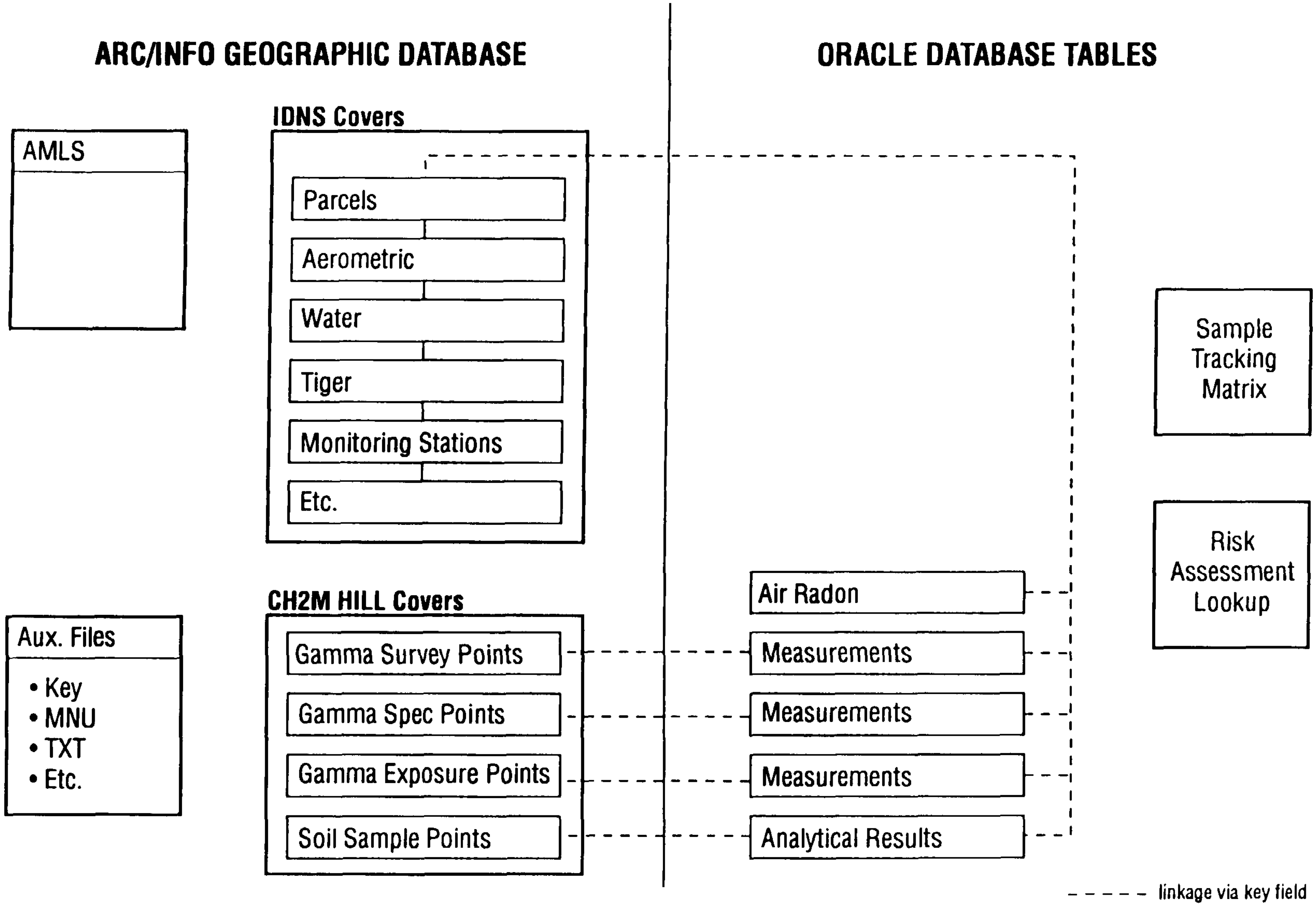


Figure 2-2
Generalized Database Structure
Residential Areas Site Work Plan

The DBMS will contain tabular data such as analytical results, stored as tables in Oracle. The tabular DBMS will use a relational data model where the data are contained in a number of separate tables, but are related through one or more key fields. Each table consists of a row of column headings or data fields, and many rows of data (or records) containing values for those fields.

For purposes of discussion, the GIS and DBMS can be considered separate databases; however, functionally they are linked together by the Database Integrator in Arc/Info. Much of the tabular data in the DBMS are attributes of the geographic features stored in the GIS. The linkages between the geographic features and the tabular attribute data are provided in selected key fields: the parcel identification or sample identification. For example, the soil sample point locations are maintained as an Arc/Info cover, but are also linked via a sample identification code to the analytical results obtained for those samples. Thus, it is possible in Arc/Info to plot the sample locations and also to symbolize or color them according to a field of analytical data stored in an Oracle table. It is also possible to reference and operate upon only the tabular data files, while using Oracle separately from Arc/Info.

Database System Applications

DBMS applications include query, analyses (e.g., risk analyses), and reporting of data stored in the Oracle tabular database.

GIS applications will support the RI/FS/risk assessment tasks through the automation of geographic map analyses and display. The use of GIS for these purposes can typically allow for greater efficiency, better QC and reproduction, and higher aesthetic quality in the production of maps than is practical using manual methods. The production of GIS presentation graphics also facilitates communication of technical issues and analytical results to public agencies and the general public. It is expected that the project will require certain analytical operations to be performed by the GIS with resultant graphics and/or reports prepared to support task activities. GIS will be used to produce hard-copy maps for intermediate uses such as QC, for analytical use by the RI/FS/risk assessment staff, for inclusion in the RI/FS reports, and for presentation at public meetings.

Basis of Estimate

- The DBMS will be operated continuously from January 1994 through October 1996 to support field and reporting activities. One hundred sixty eight P2 hours per month for 34 months (5,712 hours) will be used to run the DBMS. Additionally, 40 P2 hours will be used for system setup.

- Five hundred five P3 hours will be required to set up and trouble shoot the GIS portion of the DBMS through the project duration.

- Five hundred twenty P2 hours will be used to set up and support the DBMS portion of the system.
- Sixty T2 hours will be used to set up the hardware configuration for the system.
- System acquisition cost will be $115,187.

Subtask SA.DV – Data Validation

Task Description

The purpose of data validation is to provide a QA review of the data for the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters so that only data considered to be of known defensible quality are used in making decisions regarding corrective actions.

Data validation will be conducted by project personnel for radiological data. Project-specific procedures/requirements have been developed for radiological data validation. Specific data validation procedures are included in the QAPjP.

Basis of Estimate

- It is assumed that 2,000 in-situ gamma spectroscopy packages will be validated at an estimated 0.5 P3 hours per package for a total of 1,000 P3 hours.
- Validation of 5,874 (5,478 from soil sampling plus 396 from pilot study) soil sample results will take 0.75 P3 hours per sample for a total of 4,405 P3 hours.
- Validation of 2,000 Rn/Tn sample results will take 0.5 P3 hours per sample for a total of 1,000 P3 hours.
- Validation of exposure/dose rate measurements will require 160 P3 hours.

Section 3
Project Schedule

Figure 3-1 shows the schedule for the RI/FS for the Residential Areas site project. The schedule is based on the assumptions presented under each subtask. It is also based on the following assumptions:

- A 35-day turnaround of chemical laboratory analyses will be provided, followed by data validation within 14 days after receipt of the last analyses results.

- The EPA review periods of planning deliverables (Work Plan, SAP, HSP) will be 2 weeks.

- IDNS will provide 2-day turnaround of onsite laboratory gamma spectroscopy results.

- The EPA review periods of reports will be 30 days.

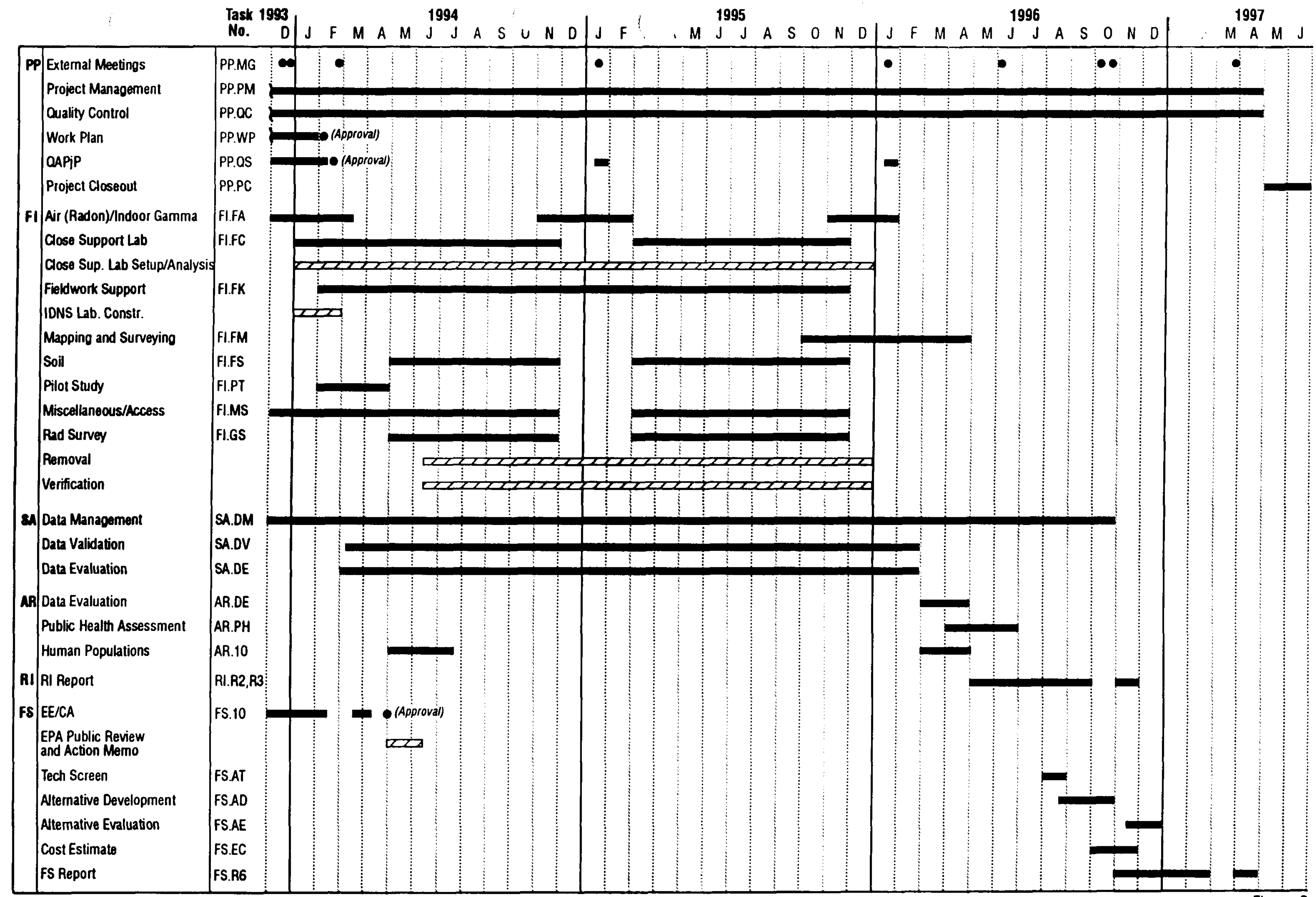
- The EPA approval of the final work plan, SAP, and EE/CA will be within 2 weeks of submittal. Notice-to-proceed will be given with approval of the SAP.

- IDNS will have constructed the onsite laboratory by the end of February.

- The public review period of the EE/CA and time for EPA to produce the removal action memorandum will not exceed 6 weeks.

- Removal activities will be completed within 1 month of the completion of discovery activities.

Table 3-1 summarizes the major deliverables for the project.



LEGEND: CH2M HILL Activity   Critical Team Member Activity

Figure 3-1
Schedule
Residential Areas Site Work Plan

Table 3-1
Project Deliverables

Deliverable	Date
Draft Work Plan	December 6, 1993
Draft QAPjP	January 21, 1994
Final Work Plan	February 4, 1994
Final QAPjP	February 25, 1994
Draft EE/CA	February 27, 1994
Final EE/CA	April 7, 1994
Phase I Indoor Air Monitoring Technical Memorandum	April 15, 1994
Draft RI Report	September 30, 1996
Alternative Development Technical Memorandum	October 30, 1996
Final RI Report	November 29, 1996
Draft FS Report	February 27, 1997
Final FS Report	April 28, 1997

Section 4
Project Costs

The estimated project costs for the Kerr-McGee Residential Areas site EE/CA and RI/FS are submitted under separate cover. Assumptions used for the development of the costs are presented under the basis of assumption for each project task. Major assumptions used for every task include the following:

- The budget is dependent on the schedule. If the schedule is extended, the incurred costs will also increase beyond those estimated. Certain activities, such as project management, must occur to a minor degree even if no deliverables are being produced. Also, delays that result in additional work being conducted in a later year will result in higher labor costs.

- Computer expenses are based on one-third of the professional hours for non-field related tasks plus 100 percent of the database, graphics, and word processing support.

- Per diem for project personnel in the Chicago area is costed at $142 per day.

- Per diem for project personnel in the Oak Ridge area is costed at $80 per day.

Section 5
Project Management Plan

The work assignment will be managed out of CH2M HILL's Oak Ridge, Tennessee, office. Technical personnel will come from this office and CH2M HILL's Milwaukee and Gainesville, Florida, offices. Jesse Tremaine will serve as the Site Manager and will work directly with the Region V Work Assignment Manager. Mr. Tremaine will have primary responsibility for this work assignment.

The project organization is shown in Figure 5-1. A site team has been selected to support Mr. Tremaine on the basis of each member's qualifications and experience with technical issues to be addressed at the site. Currently, the following individuals have been identified: George Stephens will be the Assistant Site Manager and, as such, will coordinate the technical activities through the assigned task managers. He will also oversee and approve all data evaluation and corresponding activities as the data evaluation task manager. A reports task manager will be assigned to oversee technical content and production of the EE/CA, RI, and FS. A database task manager will be assigned to oversee all interfacing with other systems, programming, data entry, and database report generation. A field activities task manager will be responsible for coordinating all field activities including access, sampling, surveying, and other data collection activities.

Schedule Control

As the project progresses, the Site Manager will monitor the actual progress of the project against the task schedules and due dates for deliverables. The Site Manager will be responsible for maintaining and updating the project schedule as appropriate.

The Site Manager will inform the Work Assignment Manager of known or anticipated schedule changes. If tasks that are within the control of CH2M HILL fall behind schedule, the Site Manager will develop and outline methods available to maintain the overall project schedule. If schedule changes occur as a result of actions beyond the control of CH2M HILL, the Site Manager will inform the Work Assignment Manager. The Site Manager also will assist in determining whether the change requires schedule modification to the Work Assignment requiring approval of the Project Officer and/or Contracting Officer.

Cost Control

This work plan includes a detailed summary of projected labor and expense costs broken down by individual activities and tasks. The cost monitoring system for this project will provide the Site Manager with a monthly report of current and cumulative site costs down to the subtask level. This monitoring system will be used to track budget against actual

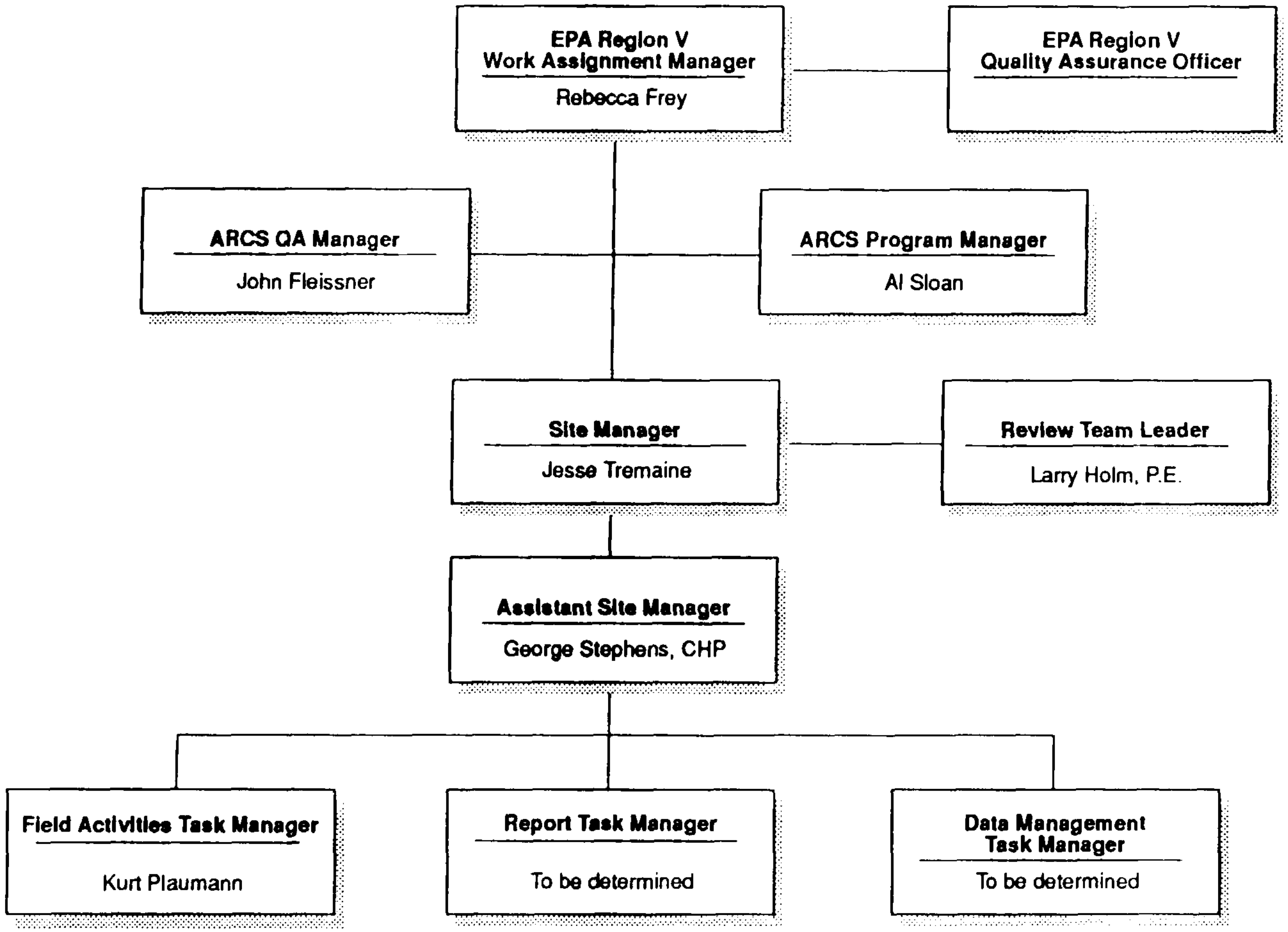


Figure 5-1
Project Organization
Residential Areas Site Work Plan

expenditures on individual site activities and will give the Site Manager a clear indication of deviations in project delivery costs.

The Site Manager will keep the Work Assignment Manager informed of the status of the budget. If the costs of tasks within the scope of work are anticipated to exceed the established budget, the Site Manager will alert the Work Assignment Manager before a change in costs occurs and will work with the Work Assignment Manager, Project Officer, and Contracting Officer to realign costs. Available project management methods include shifting funds from other tasks, reducing the level-of-effort on individual tasks (if technically feasible), reducing the scope of individual tasks (if technically feasible), and requesting additional funds as a last resort. Changes in the scope of work or in the assumptions made in this scope that will result in a change in costs will be identified to the Work Assignment Manager as soon as possible so that appropriate actions can be made.

The Site Manager will monitor and approve expenditures and travel costs, and will check subcontractor invoices for reasonableness and for compliance with the terms of their contracts. No subcontractor charges in excess of contracted budgets will be authorized or paid without clear documentation of their validity. If the subcontractor costs exceed the amount approved by EPA, reapproval will be obtained.

Coordination with EPA, PRP, and Other Parties

The Work Assignment Manager for EPA is Rebecca Frey at (312) 886-4760. Unless otherwise directed, the Work Assignment Manager is the sole contact for CH2M HILL. Questions, comments, and communications from CH2M HILL will be to the EPA and will be coordinated through the Site Manager. Outside questions and comments to CH2M HILL will be directed to EPA. CH2M HILL will have contact with other involved parties (State of Illinois) as approved by the EPA.

Quality Control

Quality control in this project will be led by the Review Team Leader, Larry Holm. His role will be to support the Site Manager in project management activities and to act as the coordinator of CH2M HILL internal reviews. All deliverables for the EPA will be reviewed. These reviews will provide technical quality and readability of deliverables. The Review Team Leader will also be involved in the planning activities conducted at the beginning of and during the project. This allows the Review Team Leader to better understand the project and to provide initial direction to the project.

Works Cited

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Client Proj No.: 71-5LQV
Master Project: 6565800

Micro Workplan
Standard Task Summary (Includes Fee)
Kerr McGee Residential Areas, IL
TREMAINE J M

Report PRJ200
Page 1
Run Date: 03/23/94
Run Time: 10:08:20
As Of: 02/94

SUBTASK Code	Description	Status	-Project To Date- Prof. Hours	Total Cost	-Est To Complete- Prof. Hours	Total Cost	-Est At Complete- Prof. Hours	Total Cost	-----Budget--- Prof. Hours	Total Cost
Administration & Program Management: 65658AM										
AS	Admin. & Program Mgmt. Services	P	0	0	92	10713	92	10713	0	0
ZZ	General	P	0	0	0	0	0	0	0	0
		Total	0	0	92	10713	92	10713	0	0
Assessment of Risks: 65658AR										
10	Human Populations	P	0	0	304	25393	304	25393	0	0
DE	Data Evaluation	P	0	0	360	29904	360	29904	0	0
PH	Public Health/Environmental Assessment	P	0	0	1052	95405	1052	95405	0	0
ZZ	General	P	0	0	0	0	0	0	0	0
		Total	0	0	1716	150702	1716	150702	0	0
Enforcement Support: 65658ES										
MS	Miscellaneous Support	P	0	0	300	32943	300	32943	0	0
SS	Enforcement Support	P	0	0	300	32938	300	32938	0	0
ZZ	General	P	0	0	0	0	0	0	0	0
		Total	0	0	600	65881	600	65881	0	0
Field Investigation: 65658FI										
FA	Fieldwork - Air	A	432	27555	3412	386849	3844	414404	791	91320
FC	Fieldwork - Close Support Lab	A	0	0	798	105943	798	105943	150	22000
FK	Fieldwork - Support	A	0	0	4840	610180	4840	610180	0	0
FM	Fieldwork - Mapping and Surveying	P	0	0	2700	205211	2700	205211	0	0
FS	Fieldwork - Soil	A	0	9	1870	155493	1870	155502	275	30000
GS	Radiological Survey	A	0	0	17508	2232067	17508	2232067	0	0
MS	Miscellaneous Support	A	175	11403	2194	157696	2369	169099	275	27000
PT	Pilot Testing	A	112	7837	1792	170145	1904	177982	850	75000
ZZ	General	A	56	5472	0	322	56	5794	0	0
		Total	775	52276	35114	4023906	35889	4076182	2341	245320

Feasibility Study RIFS Report: 65658FS

Internal Standard Tasks, Subtasks, Milestones Excluded.

Client Proj No.: 71-5LQV
Master Project: 6565800

Micro Workplan
Standard Task Summary (Includes Fee)
Kerr McGee Residential Areas, IL
TREMAINE J M

Report PRJ200
Page 2
Run Date: 03/23/94
Run Time: 10:08:26
As Of: 02/94

SUBTASK Code	Description	Status	-Project To Date- Prof. Hours	Total Cost	-Est To Complete- Prof. Hours	Total Cost	-Est At Complete- Prof. Hours	Total Cost	-----Budget--- Prof. Hours	Total Cost
Feasibility Study RIFS Report: 65658FS (con't)										
10	EE/CA	A	499	42348	501	47406	1000	89754	0	0
AD	Alternatives - Development & Screening	P	0	0	184	15186	184	15186	0	0
AE	Alternatives - Evaluation	P	0	0	460	44406	460	44406	0	0
AT	Alternatives - Technology Screening	P	0	0	124	10119	124	10119	0	0
EC	Estimates - Cost	P	0	0	166	16917	166	16917	0	0
MS	Miscellaneous Support	C	123	7863	0	707	123	8570	0	0
PT	Pilot Testing	A	0	0	0	0	0	0	0	0
R5	Report - 1st draft FS Report	P	0	0	0	0	0	0	0	0
R6	Report - Subsqnt Draft/Final FS Report	P	0	0	480	47049	480	47049	0	0
ZZ	General	A	152	10655	0	873	152	11528	0	0
		Total	774	60866	1915	182663	2689	243529	0	0
Project Planning - RIFS: 65658PP										
10	Mini Work Plan	A	157	13767	0	902	157	14669	275	28000
20	Mini QAPP	A	111	10078	0	638	111	10716	275	28000
MG	Meetings (External)	A	189	23612	536	71413	725	95025	275	30000
PC	Project Closeout Procedures	P	0	0	160	27299	160	27299	0	0
PM	Project Management	A	603	55587	4183	397602	4786	453189	275	26000
QC	Quality Control	A	166	15643	528	69599	694	85242	275	26000
QS	QAPP/SSP/FSP	A	903	86210	92	14835	995	101045	450	50000
WP	EPA Workplan	A	1211	112996	108	18251	1319	131247	850	75000
ZZ	General	A	0	170	0	0	0	170	0	0
		Total	3340	318063	5607	600539	8947	918602	2675	263000
Remedial Investigation Reports: 65658RI										
R2	Report - 1st Draft RI Report	P	0	0	890	89010	890	89010	0	0
R3	Report - Subsequent Draft(s)/Final RI Rp	P	0	0	420	41059	420	41059	0	0
TM	Technical Memorandum	P	0	0	0	0	0	0	0	0
ZZ	General	P	0	0	0	0	0	0	0	0
		Total	0	0	1310	130069	1310	130069	0	0

Internal Standard Tasks, Subtasks, Milestones Excluded.

Client Proj No.: 71-5LQV
Master Project: 6565800

Micro Workplan
Standard Task Summary (Includes Fee)
Kerr McGee Residential Areas, IL
TREMAINE J M

Report PRJ200
Page 3
Run Date: 03/23/94
Run Time: 10:08:32
As Of: 02/94

SUBTASK Code	Description	Status	-Project To Date- Prof. Hours	Total Cost	-Est To Complete- Prof. Hours	Total Cost	-Est At Complete- Prof. Hours	Total Cost	-----Budget--- Prof. Hours	Total Cost
Sample Analysis/Validation: 65658SA										
DE	Data Evaluation	P	0	0	5424	507824	5424	507824	0	0
DM	Data Management	A	0	0	6837	597808	6837	597808	0	0
DV	Data Validation	A	0	0	6566	483533	6566	483533	0	0
ZZ	General	P	0	0	0	0	0	0	0	0
	Total		0	0	18827	1589165	18827	1589165	0	0
	Master Project Total		4889	431205*	65181	6753638	70070	7184843	5016	508320

Internal Standard Tasks, Subtasks, Milestones Excluded.
* With invoiced fee only (see PRJ090 for Total with estimated full fee).